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NEW YORK, MAY, 1891.

THE offices of the RAILROAD AND ENGINEERING JOURNAL were removed on May 1 to the new building Nos. 45, 47 and 49 Cedar Street. The correct address of the JOURNAL is now, therefore, No. 47 Cedar Street, New York City.

AN important order has been issued by the Secretary of the Navy vacating all positions of foremen and master mechanics in the New York Navy Yard from June 1. These positions are thereafter to be filled by competitive examination, and a board has been appointed to make the examinations and pass on the qualifications of the candidates. The examinations will be open to all comers, who are required to make application to the Commandant of the yard by May 7, and to present evidence of citizenship, good character, and of the fact that they have had experience in that kind of work in which they seek employment.

It is understood that this is the beginning of the general application of the Civil Service system to all the navy yards, and that appointments to positions in all grades are hereafter to be based solely on qualifications for and experience in the work. There is no doubt that a full application of this system will secure a much better force than has heretofore been employed, and that the benefits of the plan will soon be apparent, especially in the great construction yards at New York and Norfolk. The examinations for the Norfolk Yard will be made by the Board a month later than those at New York.

IRON production continues to decrease somewhat, the *American Manufacturer's* report for April 1 showing 231 furnaces in blast on that date, having a total weekly capacity of 113,316 tons of pig iron. This is a decrease during April of 7.6 per cent. in the number of furnaces and of 6.2 per cent. in capacity. As compared with April, 1890, the decrease in number of furnaces in blast was 36.1 per cent., and in capacity 39.6 per cent.

Part of the reduction in April was due to the coke strike in Pennsylvania, where a number of furnaces now out of blast will start up as soon as they can obtain a steady supply of fuel. The Southern furnaces generally continue active and their production large.

THE first railroad bulletin issued by the Census Office is on the railroads of New England, and it gives the following comparative figures for the business years 1880 and 1889:

	1889.	1880.	Increase, per cent.
Mileage of roads	6,942	6,021	15.7
Locomotives in use	2,151	1,616	33.1
Passenger-train cars	3,803	2,622	45.1
Freight cars	49,140	35,051	40.3
Passengers carried	103,374,387	52,221,338	97.9
Passenger-miles	1,551,590,703	872,106,355	77.9
Tons freight carried	35,295,896	24,003,967	47.0
Ton-miles	2,313,321,712	1,394,392,088	65.9

Railroad traffic in New England has probably changed less than in any other section of the United States during the past decade, but there are still some marked differences in the table. Thus, with an increase of only 15.7 per cent. in mileage there was a gain of 77.9 per cent. in passenger traffic, and of 65.9 per cent. in freight traffic. The average freight haul increased considerably, showing a relative gain in through business, but the average passenger journey decreased considerably, a result probably of the great growth of cities and increase in suburban residents.

The average passenger fare decreased from 2.19 to 1.92 cents per passenger-mile, and the average freight rate from 1.84 to 1.47 cents per ton-mile. The tendency to lower rates exists here as elsewhere, but the reduction in freight rates was less marked, owing to the greater proportion of local and high-class freights.

The average number of employés per 100 miles of line in 1889 was 761, of whom 220 were employed in maintenance of way and structures, 121 in maintenance of equipment, 398 in conducting transportation, and 22 in general administration. In ten years the number of employés per 100 miles has increased about 35 per cent., but the proportion to traffic has slightly decreased.

The average equipment per 100 miles of line last year was 33 locomotives, 58 passenger cars, and 752 freight cars. It is to be noted that there has been a considerable increase in the average work done by both locomotives and cars.

The increase in the total income for ten years was 41.7 per cent., but that in expenses was somewhat greater, so that there was an increase of only 28.2 per cent. in the net earnings.

IN a curious paper recently read before the Geographical Society in Paris, M. de Lapparent, a well-known French Geologist, has made a careful calculation of the amount of solid matter yearly carried off into the ocean by the action of the rivers of the world and by other causes. He estimates that the reduction of the average height of the surface of the solid land is 0.000155 meter (0.006 in.) each year. Making allowance for the corresponding rise in the bed of the ocean, and taking no account of the occurrence of volcanic and other exceptional phenomena—the general tendency of which is to hasten the process of disintegration—M. de Lapparent thinks that in about 4,500,000 years the solid land will have ceased to exist, and the surface of the earth will be covered with water. By that time our descendants of the human race will have disappeared, unless they should gradually develop into a purely aquatic species.

The prospect is too remote, however, to cause us any anxiety, or to make a market for any patents for marine dwellings or floating islands for enterprising inventors.

THE first surveying parties for the Intercontinental Railroad left New York early in April, under charge of Messrs. W. F. Shunk and J. Imbrie Miller as Supervising Engineers. The parties included a number of engineers, and will begin their operations in Ecuador. Other parties will be put in the field shortly in Central America.

IN our account of the surveys of the Siberian Railroad, it was stated that the building of the Oussouri section, which extends from Vladivostok, on the Pacific Ocean, to Grafskaia, on the Oussouri, and which is to connect the chief Russian port in Eastern Siberia with the extensive navigable system of the Amour, had been postponed for the present. This statement was true at the time it was written, but since then arrangements have been made for the immediate commencement of work. The money for building the road has been provided, and the staff of engineers started from St. Petersburg early in March. These engineers will be carried from Odessa to Vladivostok on a Russian war-ship, and as the voyage will take about 40 days, the opening of the work was expected to take place early in May. The Engineer in charge of construction is Mr. A. Oursatti, who had charge of the preliminary surveys, and his chief assistant is Mr. T. Dox.

As material for construction is abundant along the line, the grading and other work will proceed rapidly. Several tunnels are required, but they will not be difficult of construction.

The actual commencement of work on this end of the Siberian Railroad will be made an occasion of considerable ceremony, and the Czarovitch will be present at the opening ceremonies.

Work will soon be begun on the line in Western Siberia, and arrangements are now being made for the preliminary works, construction of bridges, etc.

PIRACY IN THE FRANKLIN INSTITUTE.

WE regret to be obliged to record that the venerable and dignified Franklin Institute has been the victim of unscrupulous imposition. The April number of its *Journal* of the Institute contains the first part of a paper on Riveted Joints in Boiler Shells, by William Barnet Le Van, which, its readers are informed, was "read at the stated meeting of the Institute, held November 19, 1890." It is our painful duty to announce that the greater portion of that part of the paper which is published in the April number of the *Journal*, including the engravings, was copied, without credit or quotation marks, or, in other words, was purloined from the *Railroad Gazette* of August 12, 1871, pages 222 and 223; January 13, 1872, pages 18 and 19; and February 10, 1872, pages 64 and 65, where it was published as editorial matter. The same articles were afterward republished in a little volume called "Coyne & Company's Railway Officials' Annual," issued by that firm in Chicago in 1872. The assumed author of the paper read before the Franklin Institute has published what he has copied from the editorial articles referred to, with very slight alterations, and has apparently embodied it in his paper, and read it to the Institute as his own production. This, it need hardly be said, is a grave offense. Mr. Le Van is an active member in the Institute. It will be interesting to learn what action it will take with reference to this delinquency of one of its own members.

REMOVAL.

THE office of the RAILROAD AND ENGINEERING JOURNAL has been removed from No. 145 Broadway to the Stokes Building, No. 47 Cedar Street. To those with a limited acquaintance with localities in New York, it may be said that Cedar is the second street north of Wall, and runs parallel with it. The Stokes Building is a new office structure between Nassau and William streets, and is ten stories high. The office of the JOURNAL is on the eighth floor, and overlooks the East River, Brooklyn Bridge and city. A view from one of the windows of the new office is given on another page. Our patrons and friends are invited to call and bring one or more new subscribers with them.

ENGLISH AND AMERICAN LOCOMOTIVES.

IN reverting to this subject again an explanation, or apology perhaps, is due to our esteemed contemporary, *The Engineer*, of London. On January 9 of this year it published an article with the following introduction:

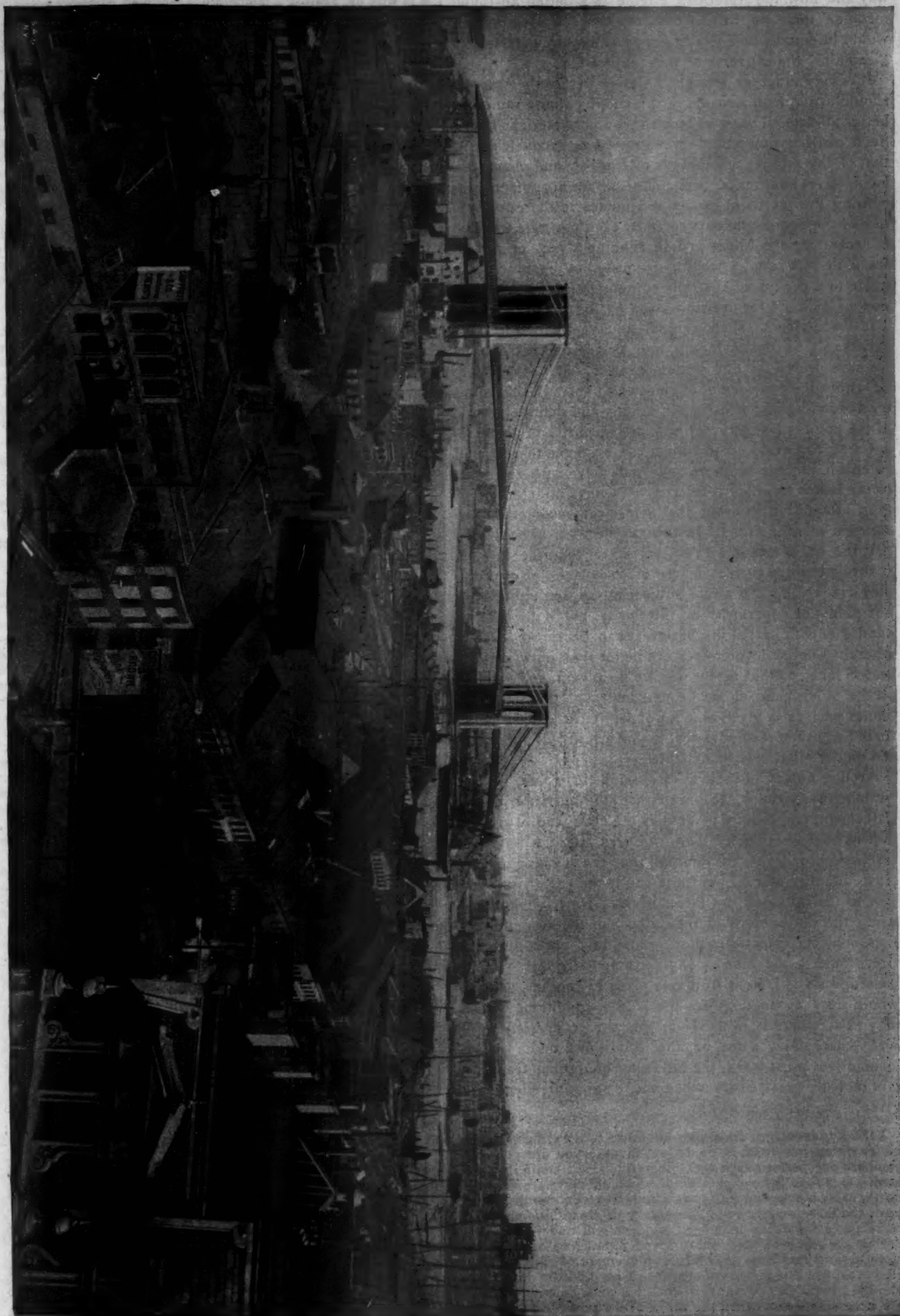
> Several weeks have passed since, in response to a species of challenge published by the United States *Engineering News*, we published a detailed statement of the working expenses of the principal railways of Great Britain. Our contemporary maintains a prudent silence concerning these figures. Mr. Forney twits our contemporary, and announces that he must take up the cudgels himself for the American locomotive.

The copy of *The Engineer* referred to was received in this country while the writer was absent from home, and on his return his attention was not called to the article it contained until about two months after it appeared, and it was only at that late date that it was known to him that it had been written or published. That is the reason why no reference has been made to it in these pages until this late date.

Near the close of it the editor of *The Engineer* deposits a chip on his shoulder by saying that "probably Mr. F—— will have something to say in reply to this article." It seems desirable that a newspaper discussion of a subject like this should, as far as possible, be impersonal, but as *The Engineer* has seen proper not to be governed by that by-law of the journalistic code, it remains only to say that the editor of this paper does not propose to abandon his attitude of an independent commentator in this discussion.

In the sort of desultory skirmishing in which this JOURNAL has engaged during the somewhat quadrilateral discussion of the subject under consideration we have endeavored to assume an interrogative rather than an affirmative attitude. In other words, we have endeavored to be governed by a spirit of inquiry, and will try to ascertain, if possible, both the merits and demerits of the locomotives which are designed and built on this and on the other side of the Atlantic.

In the early stages of this discussion *Engineering News* —somewhat rashly, as we then thought—accepted a challenge from *The Engineer* "to explain precisely in what



VIEW FROM OFFICE WINDOW OF THE RAILROAD AND ENGINEERING JOURNAL.

way and how the American engine is a better all-round machine than its British contemporary." Seemingly it would be equally rash if *The Engineer* should undertake to "explain" the converse of this proposition.

It is very much as though a native of South America should argue with a citizen of this country that a mule is a better all-around beast of burden than an American horse. Such a discussion would probably be as inconclusive as that of the relative advantages of English and American locomotives has thus far been. To limit the arguments concerning the merits of mules and horses to the one question of the quantity of oats eaten by each per mile traveled in ascending the Andes and in running a race on a race-track in this country would obviously not be much of a guide to a person in Australia contemplating the importation of animals for drawing loads or for cavalry service. The discussion of such general and vague issues must necessarily be unconvincing, and that is one reason why we have jeered at our contemporaries. But it ought to be within the province of engineering papers in this country and in England to ascertain exactly and definitely some of the points of superiority and of inferiority of their respective engines, and to collect the evidence thereof and submit it so as to be more or less decisive with reference to the issues to which it relates. We have no intention of even attempting to prove that American locomotives are superior in all points to British engines, nor of admitting that the latter are in all respects better than the former. It surely implies a great degree of ignorance—or of prejudice—regarding the whole subject to say that either have not points of superiority or inferiority, but if by careful, candid and impartial discussion it can be shown exactly wherein English locomotives are better than ours, and the reason for it, to that extent will we be advantaged; and if, on the other hand, it can be demonstrated that our machines perform a given amount of service at less cost than their English contemporaries, to that extent will our brethren on the other side be benefited.

At the outset of such a discussion, it would be advantageous, perhaps, to paraphrase the question of the Catechism, and inquire: What is the chief end of a locomotive? The editor of *The Engineer* appears from the discussion to be of the opinion that the burning of the least quantity of coal per mile run is the paramount object to be attained by locomotives. Now, obviously—using the phraseology of the Catechism again—neither of these objects constitutes the "whole duty" of a locomotive. Such a machine is an instrumentality for hauling passengers and freight from one place to another, and its whole duty is to do this—under the conditions which may exist where it is used—at the *lowest possible total cost*. To show some of the conditions under which locomotives must work, the following quotations from letters recently received from locomotive superintendents are given. One of them writes:

> I think it as well to draw your attention to the circumstances under which our road is operating, in case you are going to compare our performance with other roads not similarly situated. Our road is an expensive one in coal, as we are very far north, being blocked up with snow for about seven months in the year, the thermometer being frequently 30° to 40° *below* zero in some parts for weeks together; and you will understand that during the whole of these six or seven months we are fighting against snow and frost—our largest movement of freight being also usually in this inclement season. I need hardly draw your attention to the extra quantity of coal that must be used to make the necessary steam when the air is below zero for months, as it is with us, against a temperature, enjoyed by many roads in this country, of only a few days' frost in the year.

Another superintendent of motive power, whose road is not so far north, says:

> Our last year's locomotive report is not very good, the circumstances being such as to make it show up very badly as regards repairs and consumption of fuel, wages, etc. The road was really overtaxed with business, and being a single track, the trains were laid out on side tracks, thereby taking an extra amount of time to make their trips, which caused an excessive consumption of fuel and increased pay to train men. In addition, this trouble caused many wrecks, which will account for the high rate of repairs. . . . . .
>
> Of course you are perfectly familiar with the matter of roadway, as compared between the two countries, which is very detrimental to the American locomotive as regards the expenses.

Another one writes:

> The fast growth of our mileage has necessitated the promotion of men to such an extent that the conditions surrounding the best results from our fuel are not fully up to the British standard, where to be a first-class fireman becomes an ambition; while here it is generally considered only a short probation, to be endured only as a stepping-stone to the other side of the engine, just keeping within the bounds of security of position.

The same writer says that there is great disparity in the quality of the coal used on his line, and that on one division the engines must use 14 different kinds, varying greatly in quality.

The superintendent of motive power and machinery of one of the longest lines in this country says:

> Our locomotives have many obstacles to contend with that do not exist in Great Britain. One is, the bad quality of the water used in the boilers, causing heavy incrustation of lime and other matter, which is virtually a non-conductor of heat, and consequently demanding increased consumption of fuel in generating the steam. Our winters are, as a rule, very severe, although that of 1890 was comparatively mild; again, our house-room is very limited, and a large number of the engines are therefore obliged to remain out-of-doors, on which account we burn perhaps fully three per cent. more of coal than we otherwise would. All these conditions conspire to augment the consumption of fuel materially. The bad water also has a most destructive effect upon our flues, aided by the poor coal we are supplied with, and we are in consequence constrained to remove the flues on an average of once a year. In England, as far as I have been able to learn, a welded flue in a locomotive is unknown, as the flues remain in the boilers intact from the time they are introduced until the boilers are scrapped.
>
> I discovered the great superiority of the Welsh coal over the American product during my marine experience. I was engineer for eight years in the employ of the Cunard Line, running between New York and Liverpool.

Such are some of the conditions under which locomotives must work in this country and in some of the British colonies, and probably in other countries. The climate of Canada cannot be changed to suit its locomotives, the capital is often not available to put new roads in good condition, the morale of the men who can be employed cannot be altered suddenly to meet the requirements of roads built into new countries, nor can we afford to import coal to burn in our engines. Locomotives must be made to work in cold climates on poorly built and equipped lines; their management must be entrusted to men whose qualifications for their work are not equal to those which are available in England; they must burn coal varying greatly in quality and, in short, must work under conditions varying within very much wider limits than those which exist in an old and developed country like England. It is not said that the unfavorable conditions which have been enumerated exist on all American lines. But they do exist on many of them, and our locomotives must often

work under such circumstances. Now, it is folly to argue that our locomotives are inferior to those on English lines, because, under such unfavorable conditions, the former burn more coal than the latter do in their native land. As remarked before, the total cost of locomotive service in doing a given amount of work, under the conditions that may exist, is the only criterion of judging of their inferiority or superiority.

This total cost may be summed up under the following heads:

1. First cost and interest thereon.
2. Fuel consumption.
3. Engine service—that is, wages of locomotive runners and firemen.
4. Train service—that is, wages of conductors and brakemen.
5. Repairs.
6. Amount of service performed—that is, the number of miles run per year and the loads hauled.

The relative value of these items of expense will vary widely with the circumstances under which engines must work. Thus, if the performance of engines on the New York Elevated Railroads is compared with that of others in similar service, the comparison would not be effected by the cost of train or engine service, because each train is limited in size and must have a given number of guards and a locomotive runner and fireman. But on through freight or passenger service, on our main lines, these items become relatively of great importance, because their cost per ton or per passenger carried is reduced in an inverse proportion to the loads hauled, and no correct estimate can be made of the expense of locomotive service without taking these items into account.

As it seems doubtful whether any general comparison of English and American locomotives is likely to be either satisfactory or conclusive, we proposed, in a jocular way, during the progress of the discussion between *The Engineer* and *Engineering News*, that the editors should each design a locomotive, and publish and compare the designs. We now seriously propose to our foreign contemporary the publication of engravings in detail of one of the largest typical English express passenger locomotives, and also of one of the heaviest and most generally approved freight engines. When the total weight of these engines, in working order, without their tenders is announced we will prepare and publish similar engravings of American locomotives of an analogous type, and of as nearly the same total weight as are obtainable. Such illustrations will give actual examples of what is regarded as the best practice in the two countries, and with these examples before us and our readers comparisons of the construction and performance can be made to better advantage, probably, than is possible if the two races of locomotives are considered generically.

To the demand of *The Engineer* for data concerning the performance of American locomotives, similar to that which was "compiled from official sources" and published in its pages on November 7 of last year, it may be said here that, being heretofore only a commentator on the discussion, it was expected that the principals engaged therein would supply the evidence and the arguments. As one of the parties seems to have failed in contributing the data demanded by the other, it apparently falls to our lot to supply the deficiency. Before attempting to do this, it should be said that the compilation of such data as *The Engineer* has published is probably much easier in London than in New York. The British Board of Trade's statistics are available there, while here there is no similar organization or authority which collects such information. Many of the companies in this country do not keep any account of the fuel consumption of their locomotives; others, which keep such accounts, do not publish them. Few are kept on any uniform plan, and the only way to get such reports is by direct application to the locomotive superintendents of the different lines, who are not all either able or willing to supply them. The collection of such data as is obtainable, therefore, takes time. We have a considerable amount of material bearing upon this question, but we hope to get more. When the sources of expected supply are exhausted, a compilation will be made and submitted as evidence bearing upon the question at issue.

In the mean while, we feel quite sure that our readers will join us in the hope that our contemporary will comply with the request made in the early part of this article, and will give engravings in detail of a typical example of one of their heaviest express locomotives.

As this article has already exceeded the limits which it should occupy, only a few words can be devoted to *The Engineer's* editorial of January 9. In that it says:

Mr. Forney takes exception in a singularly disingenuous way to a statement concerning the rate at which coal is burned in locomotive fire-boxes in this country. . . . . . He coolly pits the average performance of English engines against what we believe to be an exceptional performance.

It will be observed that our contemporary uses the ugly word "disingenuous." Readers of the JOURNAL can judge whether the imputation is a just one from the following evidence:

On September 5 *The Engineer* said: "The whole discussion turns on whether a locomotive boiler has to generate more steam in a given time in America than in England," and then made the statement that "careful experiment has shown that an average performance (of English locomotives) is 500 lbs. of steam per square foot of grate per hour."

Now, if this performance was "shown" by "careful experiment," it surely was not ascertained from the working of locomotives in ordinary use. The *average* evaporation of engines during experiments extending over a greater or less period or number of miles of service must have been at the rate of 500 lbs. of steam per square foot of grate per hour. In the October JOURNAL we reported that in some experiments made on the Grand Trunk Railway, consisting of nine runs of 250 miles each, the average consumption of coal was 121.6 lbs. of coal per square foot of grate per hour, and the average evaporation was 7.35 lbs. of water per pound of coal, or an evaporation of 893.7 lbs. of water per square foot of grate per hour. This *The Engineer* calls an "exceptional performance," although it was the average result of an engine in running 2,250 miles. The number of miles run during our contemporary's "careful experiment" is not given. Was it equal to 2,250 miles?

In the same number of the JOURNAL we gave the average results of experiments made on the Hudson River Railroad in running 9,438 miles, and showed that 739.12 lbs. of water per square foot of grate per hour were evaporated. Will *The Engineer* tell its readers whether this was "exceptional," and did the number of miles run in the "careful experiments" referred to exceed 9,438?

On September 19, in commenting on the trial of the

Vauclain compound engine, the editor of *The Engineer* said :

The running time (of the Vauclain engine) was six hours, and in that time there was burned 16,389 lbs. of coal. As the grate was 25 sq. ft., a very simple calculation shows that the rate of combustion per square foot of grate per hour was over 109 lbs. We have nothing in England to equal this. About 75 lbs. per square foot of grate per hour may be regarded as *a maximum consumption* with our fastest and heaviest expresses.

In the August number of the JOURNAL it was shown that, *in tests of an hour's duration* on the 17-mile grade of the Baltimore & Ohio Railroad, 133.2, 148.1 and 193.7 lbs. of coal was burned per square foot per hour. Probably these rates of combustion are equalled nearly every day in the year on that part of the Baltimore & Ohio, and on some other railroads.

Our adversary says, " Mr. Forney coolly pits the *average* performance of English engines against what we believe to be an exceptional performance." By *The Engineer's* own admission this average was ascertained by " careful experiment," so it is not the result of every-day practice. We have also submitted the results of careful experiment. By its own admission the *maximum consumption* of their fastest and heaviest express engines is only 75 lbs. of coal per square foot per hour. We have shown that in ours the maximum is more than $2\frac{1}{2}$ times as great.

We submit that the word " disingenuous" has been misused by our contemporary.

NEEDED WATERWAYS.

FEW countries are better supplied with natural waterways than the United States, and it is to them and to the construction of some artificial ones that the country owes much of its earlier growth and prosperity. With the later great development of railroads, however, there has been a tendency to neglect the water routes, and they have not received the attention they should, although there have always been some advocates who appreciated their great economic value. It is not only as an actual carrier in comparison with the railroad that a waterway is to be estimated ; its value as a factor in competition and a regulator of rates is also to be taken into account. There is not space here, however, to support this statement by instances, the only purpose at present being to refer to one of the canal projects which have been brought before the public from time to time with varying success. Some have not, it is true, deserved success, but some, including this, certainly have a right to consideration.

The waterway which is most needed in the seaboard States is one which already exists in large part, and which needs only the building of a few comparatively short links to complete it. It is the line from Norfolk southward to Florida through the sounds and inland channels of the coast. This is already open from Norfolk nearly to the South Carolina line and from Charleston to Florida, while the gaps existing can be filled by canals easy of construction and presenting nowhere any considerable obstacles. The filling these gaps and the improvement of the existing channels would be works much less costly than many which have been undertaken and successfully carried out. Commercially it would be worth much more than it is likely to cost, while in case of a foreign war its value to the country would be almost inestimable. The ability to send ships of war on an inside line to any point on the coast would be an advantage which any strategist would recognize at once. No work of the kind can be found which is at once so feasible and offers so many advantages.

As a connection or extension of this line there may be mentioned the Florida ship canal, for which surveys were completed two years ago, and which is one of those works the postponement of which seems almost unaccountable. This is a more formidable undertaking, it is true ; but the difficulties are not by any means insurmountable. It is not any question of engineering, but only the lack of money which has so far delayed its construction.

With the Florida Canal added to the seaboard line, there would be an inland water route from New York to New Orleans which would soon become the highway for a great commerce, and might change in some degree the nature of the coasting trade. It would develop trade also and open up an outlet for much new business in lumber and other bulky freight which requires the cheapest transportation.

THE PENNSYLVANIA SHIP CANAL.

REPORT OF THE SHIP CANAL COMMISSION OF PENNSYLVANIA. *Feasibility of a Ship Canal to Connect the Waters of Lake Erie and the Ohio River.* John A. Wood, W. S. Shallenberger, Eben Brewer, John M. Goodwin, Thomas P. Roberts, Commissioners.

The Canal Commission, to which the Pennsylvania Legislature intrusted the duty of examining the country between Lake Erie and the Ohio, with a view to taking action for the building of a ship canal to connect those waters, has prepared an exhaustive report, much of the excellence of which is evidently due to Messrs. Roberts and Goodwin, the two engineers of the Commission, both of whom are well qualified for the work.

Lack of space prevents us from doing full justice to this report, but a brief presentation of the conclusions reached will be of interest. After full examination and consideration, and in view of the peculiar nature and formation of the country on the border-line between Pennsylvania and Ohio, the Commission recommends the building of a canal partly within the latter State. The line adopted starts from Conneaut Harbor, on Lake Erie, and rises to the high plateau on the State line by a series of 25 locks in a distance of 12.37 miles, the summit level, 20 miles long, being 444 ft. above the lake. Two locks bring the line down to the Greenville level, 10.35 miles long, from which there is a gradual descent into the Shenango Valley, and thence to the Ohio at Rochester, the total descent to that point from the summit level being 310.7 ft., which it is proposed to make in 22 locks.

The canal, however, will not fulfil its purpose, in the opinion of the Commission, if it ends at Rochester, but should be continued parallel to the Ohio from Rochester to Pittsburgh Harbor. It is to Pittsburgh that a large part of its traffic must go, and unless vessels can reach that city directly they will not use the canal. The extension will require the excavation of 23.44 miles of canal, and the building of two locks at Davis Island.

The total length of the proposed canal is about 125 miles, including the extension to Pittsburgh Harbor. The cross-section proposed has a width of 100 ft. at bottom—slope of banks to be $1\frac{3}{4}$ to 1—a depth of 15 ft., and proper protection of banks. The locks would be large enough to pass vessels 300 ft. long, 44 ft. beam, and 14 ft. draft, which would include all the lake ore and grain carriers except those of the very largest class. The estimated cost is about $26 400,000.

The reasons given for the line chosen are comparatively low cost, directness of route, full supply of water, and the opportunity for extending local traffic on the line itself, and by canalizing the Mahoning River. The report gives these reasons in

full; and to appreciate them properly it should be carefully read.

NEW PUBLICATIONS.

HANDBOOK FOR MECHANICAL ENGINEERS. By Henry Adams. Second Edition, revised and enlarged. (E. & F. N. Spon, London and New York.)

This book belongs to a class which is almost as difficult to review as a dictionary would be. It consists of a collection of notes which, as the author says, have been compiled from various sources.

The book begins by informing its readers that "motion is a change of place," and in the first chapter it is said that a force which, acting for unit of time, would impart unit velocity for unit mass is a *Gaussian unit*, and that the curve of quickest descent is a *brachystochrone*. The author seems to be of the opinion that by using hard names he is imparting knowledge.

The chapters or sections, as they are called, are on the following subjects: Fundamental Principles of Mechanics; Varieties and Properties of Materials; Strength of Materials and Structures; Pattern-making, Moulding and Founding; Forging, Welding and Riveting; Workshop, Tools and General Machinery; Power Transmission by Belts, Ropes, Chains and Gearing; Friction and Lubrication; Thermodynamics and Steam; Steam Boilers; The Steam Engine; Hydraulic Machinery; Electrical Engineering; Sundry Notes and Tables.

There is no good reason apparent for writing or publishing such a book. It requires no special ability; and to do it all that an ordinarily intelligent reader would need is to get the files of one or more good engineering journals, a few text and pocket-books, and then read and compile. The book before us has not the merits of a treatise, nor is it as useful as a pocket-book. It has no systematic plan; the material has been undigested, and the author has added an assumption of profundity by using hard names, Greek notation and mathematics, which will only be a puzzle to practical men.

I. IRRIGATION DEVELOPMENT. *History, Customs, Laws and Administrative Systems Relating to Irrigation and Water Courses in France, Italy and Spain.* By Wm. Ham. Hall, State Engineer. (Sacramento; State Printers.)

II. IRRIGATION IN CALIFORNIA. *The Field, Water Supply and Works in San Diego, San Bernardino and Los Angeles Counties.* By Wm. Ham. Hall, State Engineer. (Sacramento; State Printers.)

These two volumes together form a partial report on Irrigation, which was submitted by Mr. Hall, as State Engineer of California, two years ago, but which has only recently become available for general use, owing to the slow methods adopted with public documents.

Irrigation is comparatively so new a practice in the United States that the part on Italian, French and Spanish systems is really an essential and valuable feature of the report. While some of our methods are new, for all precedents and for experience we must go back to Southern Europe, India or Mexico—perhaps to China, where irrigation has been practised for many centuries, and where it probably originated.

Mr. Hall has given a very full account, with numerous illustrations, of what has already been done in the three southern counties of California, and of what was proposed at the time he wrote. Some of these projects have since been carried out, while others still remain in abeyance. The work has never been completed as originally proposed, owing to the failure of the Legislature to make proper appropriations; a neglect which is much to be regretted, as the later volumes would not only have completed the accounts of what has been done, but would also have treated of irrigation and water laws, and of other questions upon which action is much needed.

Even in its present unfinished state, however, Mr. Hall's report is a very valuable one, and contains much information that is not accessible elsewhere. It is accompanied by maps showing drainage area and rainfall distribution, and is printed in excellent shape.

BOOKS RECEIVED.

Annual Report of the City Engineer of Providence for the Year 1890: *J. Herbert Shedd, City Engineer.* Providence, R. I.; printed for the City. A special feature of this report is an appendix, giving formulæ for ascertaining the loss of head due to the friction of water in smooth pipes, with tables worked out by the same.

Improved Roads: An Address Delivered before the New Jersey State Board of Agriculture, by Chauncey B. Ripley, LL.D.

The Sioux City Bridge: A Report to Marvin Hughitt, President of the Sioux City Bridge Company, by George S. Morison, Chief Engineer. Chicago. Some extracts from this excellent monograph will be found on another page.

Reports of the Consuls of the United States to the Department of State: Nos. 124, *January, and* 125, *February,* 1891. Washington; Government Printing Office.

On the Maximum Steam Jacket Efficiency: by Professor Robert H. Thurston. Philadelphia; reprinted from the *Journal* of the Franklin Institute.

Examinations by the State Board of Health of the Water Supplies and Inland Waters of Massachusetts: Part I of Report on Water Supply and Sewerage. Boston; State Printers. This volume reaches us too late to receive the full review which it deserves in the present number.

Annali della Societa degli Ingegneri e degli Architetti Italiani: Anno V, 1890. *Fascicolo VI.* Rome, Italy; published for the Society.

Occasional Papers of the Institution of Civil Engineers. London, England; published by the Institution. The present installment of these papers includes Indian Bridges, by F. E. Robertson and E. W. Stoney, and several shorter ones.

Special Experiments with Cylinder and Journal Lubricants: by Professor J. E. Denton, Stevens Institute. New York; reprinted from *Proceedings* of the American Society of Mechanical Engineers.

Performance of 75-*ton Refrigerating Machine of the Ammonia Compression Type: by Professor J. E. Denton, Stevens Institute.* New York; reprinted from *Proceedings* of the American Society of Mechanical Engineers.

The Money Value of Solid Emery Wheels: by T. Dunkin Paret. Reprinted from proceedings of the Association for the Advancement of Science.

Emery Wheels: by T. Dunkin Paret. Reprinted from the *Journal* of the Franklin Institute.

TRADE CATALOGUES.

THE firm of Darling, Brown & Sharpe, of Providence, R. I., has issued a very handsome reproduction of the diploma awarded them at the Paris Exposition in 1889. It is artistic enough in appearance to be worth preservation.

The Westinghouse Machine Company has undertaken to advertise on a new plan, and has arranged a series of cards which will show in regular monthly succession the general character of the company's business; the leading points in favor of its engines; the points wherein they differ from other engines; the

different types made; the class of people by whom they are used, and other interesting points.

A trade catalogue of unique character is issued by the Joseph Dixon Crucible Company in the form of a package of pencils of various grades submitted for editorial consideration. No better recommendation could be found for these pencils than their constant use.

Special Tools for Railway Repair Shops: Boring, Milling, Planing and Shaping Machines: Illustrated Catalogue of Pedrick & Ayer, Philadelphia.

Frontier Iron and Brass Works, Pulverizing and Separating Machinery, Detroit, Mich.

The Tanite Company, Catalogue of Solid Emery Wheels and Grinding Machines. Stroudsburg, Monroe County, Pa.

Berry Brothers' Varnish and Japan Works, Detroit, Mich. Illustrated Description.

ABOUT BOOKS AND PERIODICALS.

THE last quarterly number of the PROCEEDINGS of the United States Naval Institute opens with the prize essay for this year by Ensign A. P. Niblack, on Enlistment, Training and Organization of Crews for the New Ships. Other articles are on Siacci's Ballistic Equations, by Professor William Woolsey Johnson; on Target Practice, by Lieutenant J. F. Meigs; on Electric Revolution Counters, by Assistant-Engineer W. D. Weaver; and on an Experimental Ammunition Cart, by Lieutenant W. W. Kimball.

A hand-book of German technical terms has been under preparation for several years by Professor J. Howard Gore, of the Columbian University at Washington, and will soon be published by D. C. Heath & Company. Professor Gore has had especial facilities for compiling such a work, and it will be appreciated by all who have occasion to read technical German, and who know how deficient the ordinary dictionaries are in technical terms.

In HARPER'S WEEKLY the first of a series of illustrated articles on Australia has been published, and others are promised. The WEEKLY recently illustrated the "whale-back" steamer *Colgate Hoyt*, and the designs for the Columbian Exhibition buildings in Chicago, and gave a very entertaining article on Patents.

Among the new books in preparation by John Wiley & Sons, New York, are the Mechanical Engineers' Pocket Book, by William Kent, and the Transition Curve Field Book, by Conway R. Howard. An inspection of the material of Mr. Howard's book enables us to say that it will be an excellent one for its purpose, and a very convenient assistant for engineers on railroad work.

In HARPER'S MAGAZINE for May the series of South American articles will be continued by one on Uruguay, by Theodore Child, and another on the Argentine People, by Bishop J. M. Walden. Colonel T. A. Dodge begins a series of short papers on Horsemanship in America. The lighter articles include several of special interest.

Among the articles in the POPULAR SCIENCE MONTHLY for April there may be mentioned the History of the Ohio River, by Professor J. F. James; Street Cleaning in Large Cities, by General Emmons Clark; What Keeps the Bicycler Upright? by C. D. Warring, and Changes in California, by C. H. Shinn. In the May number there will be an illustrated article on Ice Making and Artificial Refrigeration, by F. A. Fernald, describing a growing and important industry.

Two articles in BELFORD'S MAGAZINE, for April, on University Training, written from diametrically opposite points of view, will attract much attention. The Silver Question and Protection are also discussed in this number. While keeping up its controversial character, however, the purely literary side has not been neglected, and plenty of light reading is provided.

The National Guard of Wisconsin is the subject of the military article in OUTING for April; it is written by Captain Charles King. Composite Photography, Canoeing in the Chambly Rapids, and Esquimaux Whaling are among the other articles. In this number Captain Schuyler's paper on the Evolution of Yachting is concluded.

In SCRIBNER'S MAGAZINE for April the first of the promised series on Ocean Passenger Travel is published; it is general and historical in its nature, and has many illustrations. The Cruise of the United States Steamer *Thetis* in the Arctic is described and illustrated. An article on Right-Handedness, by Dr. Thomas Dwight, deserves a careful reading. The article in the steamship series in the May number is on the Ship's Company, and is by Lieutenant J. D. J. Kelly, U. S. N. In this number also is a paper on Broadway, by Richard Harding Davis, which is the first of a series on the Great Streets of the World.

We are requested to state that Mr. Robert Grimshaw, General Editor of the Trades Department of Funk & Wagnalls' Standard Dictionary, being desirous of making as complete as possible his list of mechanical and industrial terms, requests manufacturers of machinery and tools having important parts not found on those of other makers, or the names of which are not yet in general use, to send the name, definition and use of each such part to him at 115 Bible House, New York City.

THE DISCOMFORTS OF RAILROAD TRAVEL.

To the Editor of the Railroad and Engineering Journal:

I HAVE read with interest the article, "The Discomforts of Railroad Travel," published in your issue of February. May I ask you to request the gentleman who wrote the article to kindly blister the uniformed idiot who opens the front door of your car a quarter of a mile before the next station is reached, bawls out the supposed name of the station, leaves the door fastened open, goes to the rear door of the preceding car, and again emits a bawl. When the train stops he helps off all the younger females, lets the old ones shift for themselves, returns to the car in front, and advises the passengers that the "Nexstaishiz yaup—yaup," and then conveys the same important information to you, and then, and not until then, does he close the door of your car.

Another fiend deserves his attention; he is the engineer who might be termed a "yanker."

On reading the notices of the railroad that furnishes "The finest service in the world" (please note that this applies to any and all roads), you will find one which reads something after this manner: "Passengers taking the — P.M. train, which will arrive at Blankville at — A.M., may remain in their berths until 7 o'clock." Would that the scribe who wrote these lines, and the railroad official who dictated them, would take passage in one of these trains. He will find that when he arrives in the suburbs of Blankville that he will be rudely awakened by the detaching of his car from the train, it will be jerked this way and bumped that way without any apparent reason. At last he despairs of getting further sleep, and resolves that he will dress and leave the car. About the time he has finished dressing he will notice that the car has at last found a resting-place; but, as he has resolved to go, he goes, and, arriving at the door, finds that his car is on a siding, and upon inquiry of the porter, who by this time is sufficiently awake to make a few passes through the air with his whisk and hold his hand for the hoped-for quarter, that the depot is "right down that there track, sir, about two blocks and a half."

After walking down "that there track," dodging several freight trains, he finds the depot, and mentally and explosively resolves that the next time he takes a train in which "the passengers may remain until 7 o'clock," it will be when all the other places are closed and the walking is bad.

A. SPIKE.

A NEW SPANISH CRUISER.

THE accompanying illustration, which is taken from London *Engineering*, shows the first-class armored cruiser *Pelayo*, recently completed for the Spanish Navy by the Compagnie des Forges et Chantiers at the yards at La Seyne, near Toulon. The plans for the hull of the ship were prepared by M. Lagane, Director of the Works, and the engines were designed by M. Orsel.

The dimensions of the ship are as follows: Extreme length, 346 ft. 6 in.; width at water-line, 66 ft. 3 in.; draft of water aft, 24 ft. 9 in.; displacement, 9,900 tons. The ship is constructed of steel throughout, and is protected by a water-line belt of armor 6 ft. 10 in width, extending the whole length of the hull, and varying in thickness from 17.7 in. in the center to 11.8 in. at the ends. Above this belt the protection consists of a steel deck placed at the level of the top of the plates.

The ship has a double bottom divided into 98 water-tight cells, while the space between the bottom and the armored deck is separated into compartments by 16 transverse bulkheads and by several longitudinal bulkheads, making no fewer than 145 compartments. All of these divisions, including those in the double bottom, can be emptied by means of a collecting channel 12 in. in diameter running from end to end of the ship, and connecting with two large pumps. There are other pumps also which can be employed in addition for draining any of the compartments. The coal-bunkers are so arranged as to give additional protection to the engine and boilers.

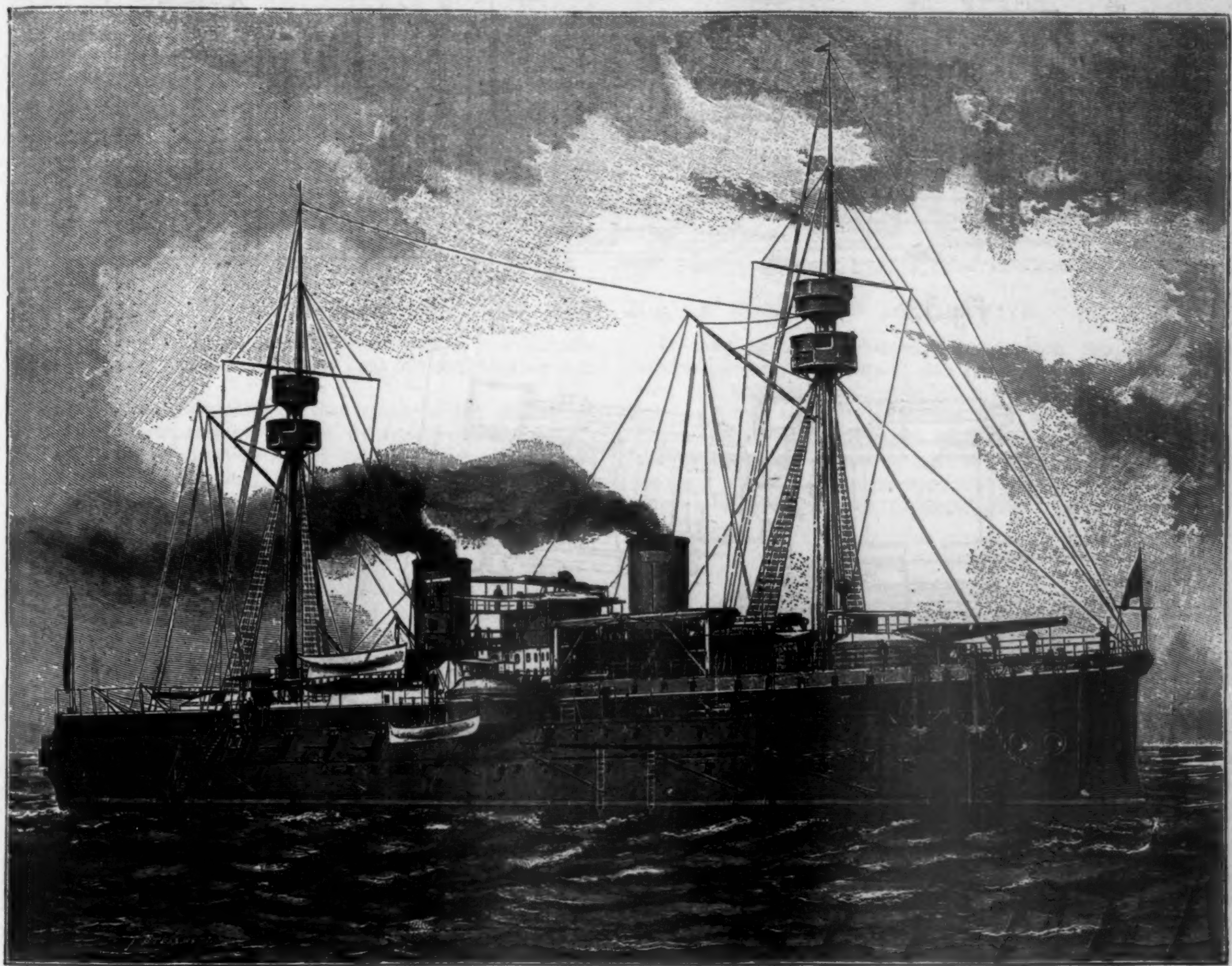
The quarters for the officers and crew are ample, and are arranged on the upper decks above the armored decks. The magazines for ammunition are in three groups arranged for convenient supply of the guns.

For ramming purposes the ship carries a heavy steel spur forward, which forms part of the framing of the vessel.

The armament consists of two 32-cm. (12.6-in.) Hontoria guns mounted, one forward and the other aft, in two barbette turrets; two 28-cm. (11-in.) Hontoria guns placed almost amidship, one on each side; one 16-cm. (6.29-in.) Hontoria gun placed well forward; twelve 12-cm. (4.72-in.) Hontoria guns placed six on each side in batteries. The secondary battery consists of a number of rapid-fire and revolving guns carried on deck and in the double tops of the military masts. There are also seven torpedo tubes carried on the lower deck.

The barbette turrets in which the 32-cm. guns are placed are protected by steel plates 13.8 in. thick, and the turrets are supported on a framing also protected by steel plates 7.9 in. thick, extending down to the armored deck, and serving as a cover for the ammunition hoists. The forward turret is placed at a height which brings the axis of the gun 31 ft. above the water-line; it has a firing angle of 250°. The rear gun has the same elevation, and a firing angle of 220°. The 28-cm. broadside guns have each a firing angle of 180°, so that they can be used either in chasing or retreating, and three heavy guns will always be available in each direction. A heavily armored shelter on the upper deck is fitted up with electric and other signal apparatus and steering gear, so that the Captain can direct the fighting of the ship in security.

The *Pelayo* has two screws, each driven by an independent compound engine, and steam is furnished by 12 return-flue boilers built for a working pressure of 80 lbs.

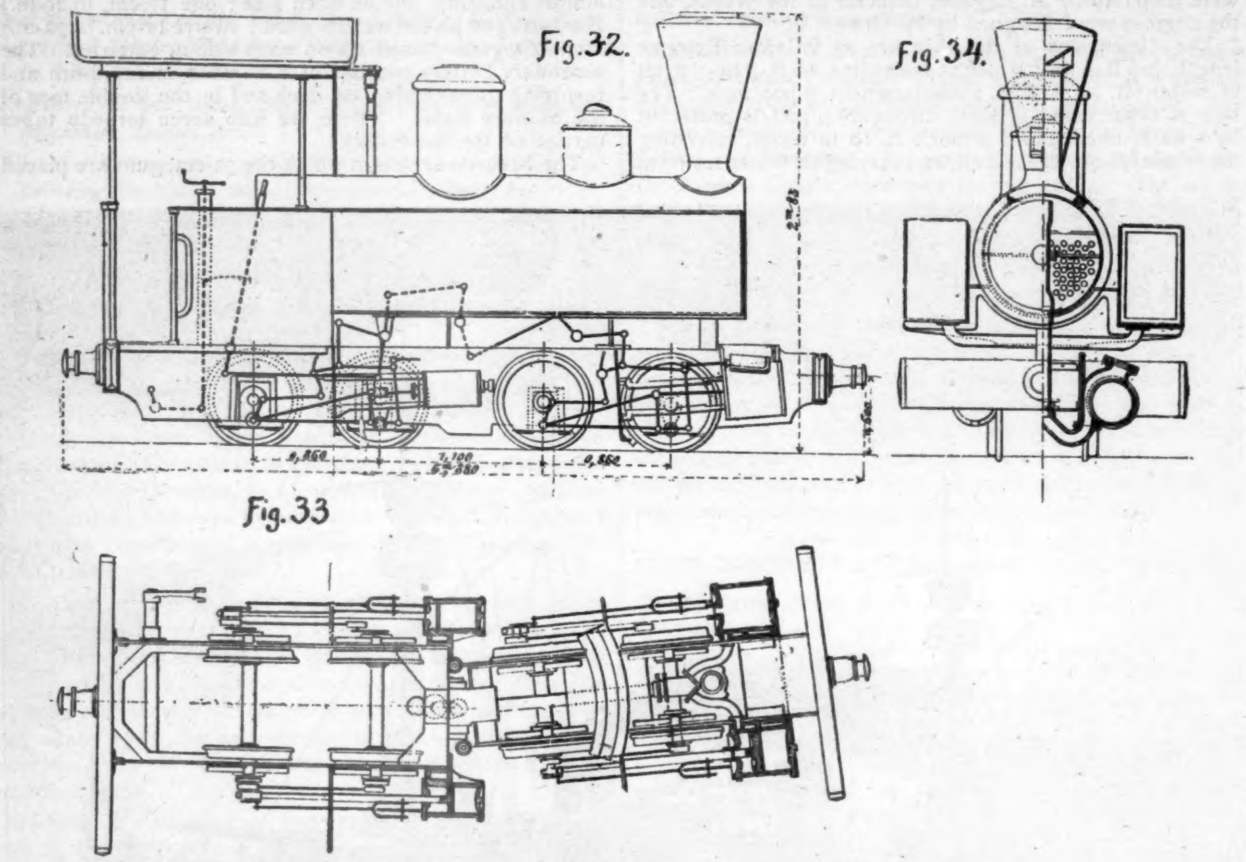


ARMORED CRUISER "PELAYO," FOR THE SPANISH NAVY.

The usual number of auxiliary engines, pumps, etc., are provided.

On the trial trip the ship reached a speed of 16.2 knots an hour with natural draft. The capacity of the coal-bunkers is 800 tons, which will give a cruising radius of 5,000 miles at a 12-knot speed, and of 7,500 at a 10-knot speed.

The Dawes patent showed both these arrangements, the engine working on cranks 180° apart and the division into two separate groups not coupled together, but without the articulation of these groups; that is to say, their placing on separate trucks. Up to the present time the form of four-cylinder engines with cranks at 180° has only been carried out once to my knowledge. The arrange-



ARTICULATED COMPOUND LOCOMOTIVE, DECAUVILLE SYSTEM.

The *Pelayo* is much of the same class as the *Maine* and *New York*, now under construction for our own Navy, although she has a somewhat greater displacement.

THE DEVELOPMENT OF THE COMPOUND SYSTEM IN LOCOMOTIVES.

By M. A. Mallet.

(Paper read before the Société des Ingenieurs Civils, Paris; translated from the French by Frederick Hobart.)

(*Continued from page* 158.)

FOUR-CYLINDER LOCOMOTIVES WITH FOUR MOTIONS.

I must here once more refer to my paper of 1877, in which I spoke of "four cylinders, two high-pressure and two low-pressure, each of these having its own valve motion. These four cylinders can act upon the same axle, and then by connecting the two cylinders of the same group on crank-pins placed at an angle of 180°, we can realize very satisfactory conditions of balance for the driving-axle, as Randolph and Elder have already done for marine engines. We can also make each group of cylinders act upon a different axle, whether these axles are coupled or not. In this last case we would have a Meyer or Fairlie compound engine, which would be a very good arrangement, because the complication would be justified both by the very principle of the engine—flexibility—and by the better working of a compound than a simple engine."

ment in two separate groups which has been made in other cases has been without coupling.

This second plan presents, again, two cases, that in which the two groups of driving-wheels are carried on one rigid frame and that where each has its own frame, these frames forming trucks which can assume a different relation to each other in passing around curves.

The only example of which I have knowledge of the arrangement of four cylinders with cranks at 180° for one group, the second group having its crank-pins at 90° with those of the first, is the engine *Vulcan* of the Scinde, Punjab & Delhi Railroad, which had high-pressure cylinders inside, 16 in. in diameter, each of which was replaced by one cylinder 17 in. in diameter in the same position as the old one, and an outside cylinder 12 in. in drameter working on a crank-pin placed on the driving-wheel at an angle of 180° with the inside crank. The stroke of the pistons was 24 in.; the diameter of the main driving-wheels and of the rear coupled wheels was 60 in. This change was made in 1884, and good results were obtained from the engine both in economy and increase of power; but I have never heard that this model has been reproduced.

An example of the type with two groups not coupled and on a single frame is given by locomotive No. 701 of the Northern Railroad of France, built by the Société Alsacienne, on the plans of M. de Glehn, No. 38 in the large table. This machine has been described, and it may be considered an excellent model, the only point to be regretted being that the large cylinders were not made greater in diameter. They should have been increased so as to give a ratio with the high-pressure cylinder of 1 : 2.30, which would have been preferable with a pressure

of 160 lbs. This is the only application so far made of this arrangement, which we must consider as much superior to that of Mr. Webb.

The form with four cylinders in two groups acting upon different axles, the axles being coupled together, has been carried out on the Paris, Lyons & Mediterranean Railroad on three types of locomotives—Nos. 47, 48 and 49 in the table—two of which were shown at the Exposition of 1889. This type has been described minutely in several papers.

The object proposed in these engines is to obtain great regularity in the moments of rotation ; but this advantage,

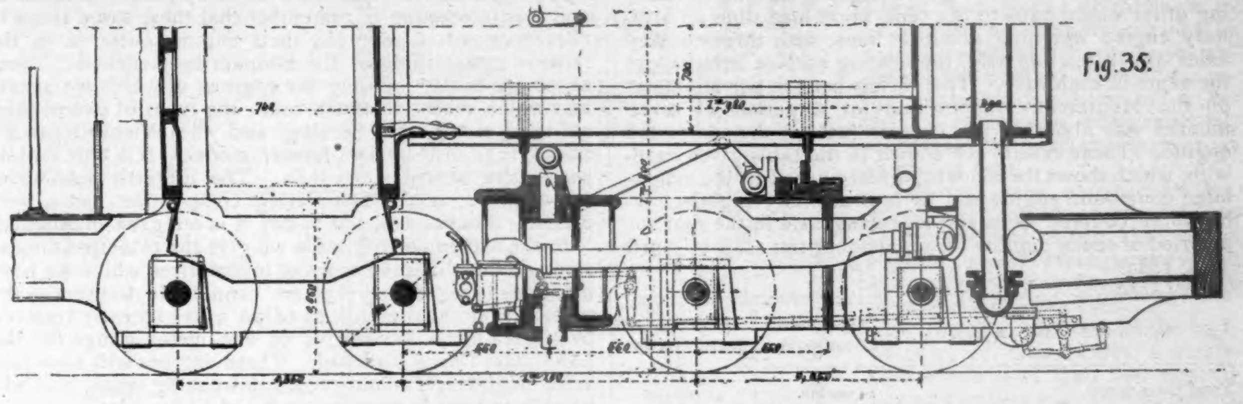


Fig. 35.

STEAM PIPE CONNECTIONS, ARTICULATED COMPOUND LOCOMOTIVE.

obtained by carefully studied combinations, has unfortunately been realized only at the cost of considerable complication.

The last arrangement of this class, which places two groups on independent frames or trucks, is that type of four-cylinder locomotive which has, so far, had the greatest number of examples. This system was worked out in 1877 and presented in 1884 under its present form. It was

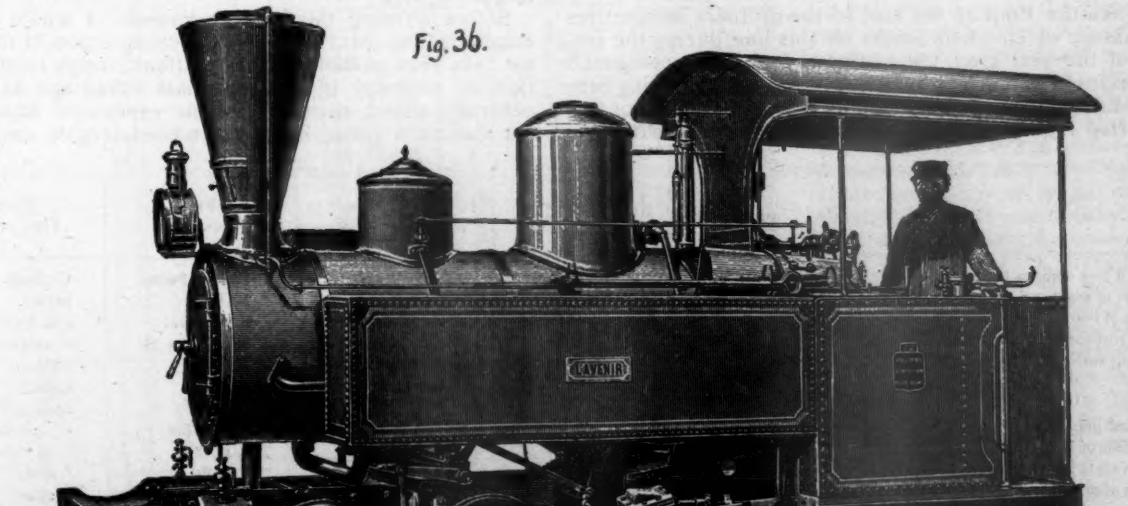


Fig. 36.

ARTICULATED COMPOUND LOCOMOTIVE, DECAUVILLE SYSTEM.

carried into practice in 1887, thanks to the intelligent co-operation of M. Paul Decauville, who readily comprehended the advantage of using on his system of railroad a type of locomotive combining great power, flexibility and the division of the load over a number of bearing points.

A common mistake which has been made in describing this machine is of representing it as carried upon two trucks. In reality there is only one truck forward, which is joined to the fixed part of the engine by the center-bearing and levers. The latter is composed of the boiler, the water-tanks and the frame, carried upon the wheels of the rear group, to which the high-pressure cylinders are attached, while the low-pressure cylinders are fixed upon the forward truck. The advantage of this arrangement is that the high-pressure steam-pipe is fixed as in an ordinary locomotive, and that the only joints required are in the steam-pipe connecting the two groups of cylinders, which carry steam at a pressure of not over 60 lbs., and in the exhaust pipe.

It may perhaps be useful to mention the conditions which govern the design of this type of engine. They were that the engine must carry, on a track of 24-in. gauge, a load of 8 or 9 tons on grades as high as 8 per cent. ; that it must pass around curves of 66 ft. radius, and that the weight must not exceed 3 tons on each axle, or 1½ tons on each wheel. The first condition required the use of an engine weighing about 12 tons, while the third required the use of four axles, and the second made it impossible to couple these four axles together, and rendered the division of the machine into two groups necessary. Both the Fairlie and Meyer type fulfilled these conditions ; but I must be permitted to consider my own as much more simple and economical in working, and I think that practice has made this very clear.

There have already been built over 30 locomotives of

this type for gauges varying from 24 to 31½ in. The best known application was that made in the Decauville Railroad at the Exposition of 1889.

Some engines of the same system have been built for roads of one meter gauge. They worked on a line of the Departmental Railroad Company and on the Durango-Zumarraga Railroad, where there are grades of 2.5 per cent., combined with curves of 328 ft. radius on the first-named line and of 236 ft. radius on the latter. The engines of the Departmental Railroad are included in the table, No. 41. On these roads the fact has been recognized that a compound engine weighing 24 tons in working order would haul 50 per cent. more load than an ordinary engine weighing about 22 tons, with three coupled axles and a leading axle, the heating surface being about the same in each case. The saving per ton per kilometer on the Montereau-Souppes line for a period of seven months was about 20 per cent. in fuel for the compound engine. These results are shown in the table given herewith, which shows the amount of fuel burned by the articulated compound engine and by four ordinary engines having three coupled axles and a bearing axle in the rear for a period of seven months—from October 1st, 1888, to April 30th, 1889.

Oct. 1, 1888—April 30, 1889.	Compound Locomotives.	Ordinary Locomotives.
Total distance run	22,222 km.	42,587 km.
Tons hauled one kilometer	854,200	1,414,500
Total consumption of fuel	153,868 kg.	317,957 kg
Fuel burned per kilometer run	6.920 "	7.460 "
Fuel burned per ton hauled 1 kilometer	0.180 "	0.285 "
Saving per kilometer run	7.24 per cent.	....
Saving per ton hauled 1 kilometer	19.92 " "	....

Note.—The consumption of fuel is equivalent to 0.5796 lbs. per ton-mile for the compound and 0.7245 lbs. for the ordinary locomotive.

When the limit of the load of the ordinary locomotives is passed, which often occurs on this line during the season of the beet crop, the saving in fuel by the compound increases to as much as 35 per cent. We are speaking here of the actual commercial economy, the consumption of fuel reported including everything—lighting fires, switching, stations, etc. On this basis we cannot report exactly the economy due to the coupound engine, which is evidently greater than that reported. On the other hand, all of this economy is not due to the compound working, because the machine is more powerful and draws a heavier load, but as it is not sensibly heavier than the other and as the double expansion here has allowed us to make this arrangement in a practical manner, at the same time really simplifying the engine, I believe that the entire saving can justly be credited to the compound.

For standard gauge I might mention the 35-ton engines in service on the Herault Railroad, shown in figs. 39 and 40—No. 43 in the table; the powerful 56-ton engines for the Central Swiss Railroad, shown in figs. 37 and 38—No. 44 in the table—both of these types having four axles; and a very heavy engine of 85 tons for the Gothard Railroad, figs. 41 and 42—No. 45 in the table—the last named having six axles. This is much the heaviest engine now existing in Europe, and has only been exceeded on this continent by some Fairlie engines recently built in England, and intended for a Mexican railroad.*

The large compound articulated locomotives for the Central Swiss Railroad were built by Maffei at Munich, and it is interesting to remember that these same shops in 1841 received a prize for their engine *Bavaria* in the famous competition for the Sömmering Railroad. These shops are to-day building the engines of which we speak, and which resemble much more the types of two of their old-time rivals, the Seraing and the Wiener-Neustadt Shops, than of their own former model. It is true that 40 years have passed since then. The Engerth locomotive, for instance, at the Sömmering competition had a very considerable success, but to-day it is not even mentioned.

In the accompanying table we give the principal dimensions of the different types of locomotives which we have mentioned, regretting that we cannot add to them at the present time the dimensions of an order recently received by Maffei for a locomotive of one meter gauge for the Landquart-Davos Railroad. These engines will have four axles, will weigh about 36 tons in working order, and will be able to haul 80 tons on grades of 4½ per cent.

To sum up, the compound articulated engine has obtained in practice a success which insures rapid development. The first engine was put under construction in the spring of 1887, and there are now over 50 of different dimensions and of different gauges in service or under construction. The adoption of this type for very powerful engines on important lines is a remarkable fact, and I hope soon to be able to present the results obtained in practice with the more recent applications—that is, the larger engines.

Before quitting this subject, however, I would like to emphasize the point that if in the construction of this type we have been guided by considerations foreign to the question of economy in fuel, this last advantage has been naturally added, since the double expansion, which was not the main point, has led to a considerable simplification in the arrangement of the steam-pipes. This is the case where, in spite of the adversaries of the system, the compound engine, which they represent as complicated, is really the opposite and does away with complication in certain delicate parts of the locomotive.

This might be the place to say something of the starting arrangements and of the valve gear used on compound engines of three or four cylinders, as we have already

	No. 1. Figs. 32-36.	No. 2. Fig. 43.	No. 3. Figs. 39-40.	No. 4. Figs. 37-38.	No. 5. Figs. 41-42.
Lines where engines are in use	Decauville.	Departmental.	Herault.	Central Swiss.	Gothard.
Builder of engines	Decauville Co.	Belfort Co.	Cail.	Maffei.	Maffei.
Gauge of road	2 ft. to 2 ft. 7½ in.	1 meter.	4 ft. 8½ in.	4 ft. 8½ in.	4 ft. 8½ in.
Grate surface	5.17 sq. ft.	8.40 sq. ft.	15.57 sq. ft.	19.38 sq. ft.	23.68 sq. ft.
Heating surface, fire-box	24.76 " "	45.07 " "	69.97 " "	86.11 " "	100.11 " "
" " tubes	215.29 " "	306.03 " "	753.50 " "	1,259.42 " "	1,560.82 " "
" " total	240.05 " "	351.10 " "	823.47 " "	1,345.53 " "	1,660.93 " "
Working pressure of boiler	170 lbs.	170 lbs.	170 lbs.	170 lbs.	170 lbs.
Diameter of high-pressure cylinder	7.36 in.	9.84 in.	12.00 in.	13.98 in.	15.75 in.
" " low-pressure "	11.02 "	14.96 "	18.11 "	21.65 "	22.83 "
Stroke of all cylinders	10.24 "	18.11 "	20.47 "	25.20 "	25.20 "
Diameter of driving-wheels	23.62 "	35.43 "	47.24 "	55.12 "	48.79 "
Distance between axles in each group	2.79 ft.	3.77 ft.	4.76 ft.	6.23 ft.	8.86 ft.
Total wheel-base	9.18 "	13.12 "	16.40 "	20.33 "	26.67 "
Capacity of water-tanks	370 gals.	793 gals.	1,116 gals.	1,321 gals.	1,850 gals.
Weight of engine empty	20,500 lbs.	41,900 lbs.	61,700 lbs.	106,000 lbs.	145,500 lbs.
Weight in working order	25,800 "	54,000 "	77,100 "	130,000 "	187,400 "
Tractive effort at rim of wheel	3,968 "	8,375 "	10,379 "	15,208 "	22,040 "
Minimum radius of curve on which engine will work	59 ft.	148 ft.	263 ft.	328 ft.	492 ft.

* These engines are exceeded in weight by the locomotives for the St. Clair Tunnel, lately completed at the Baldwin Works.

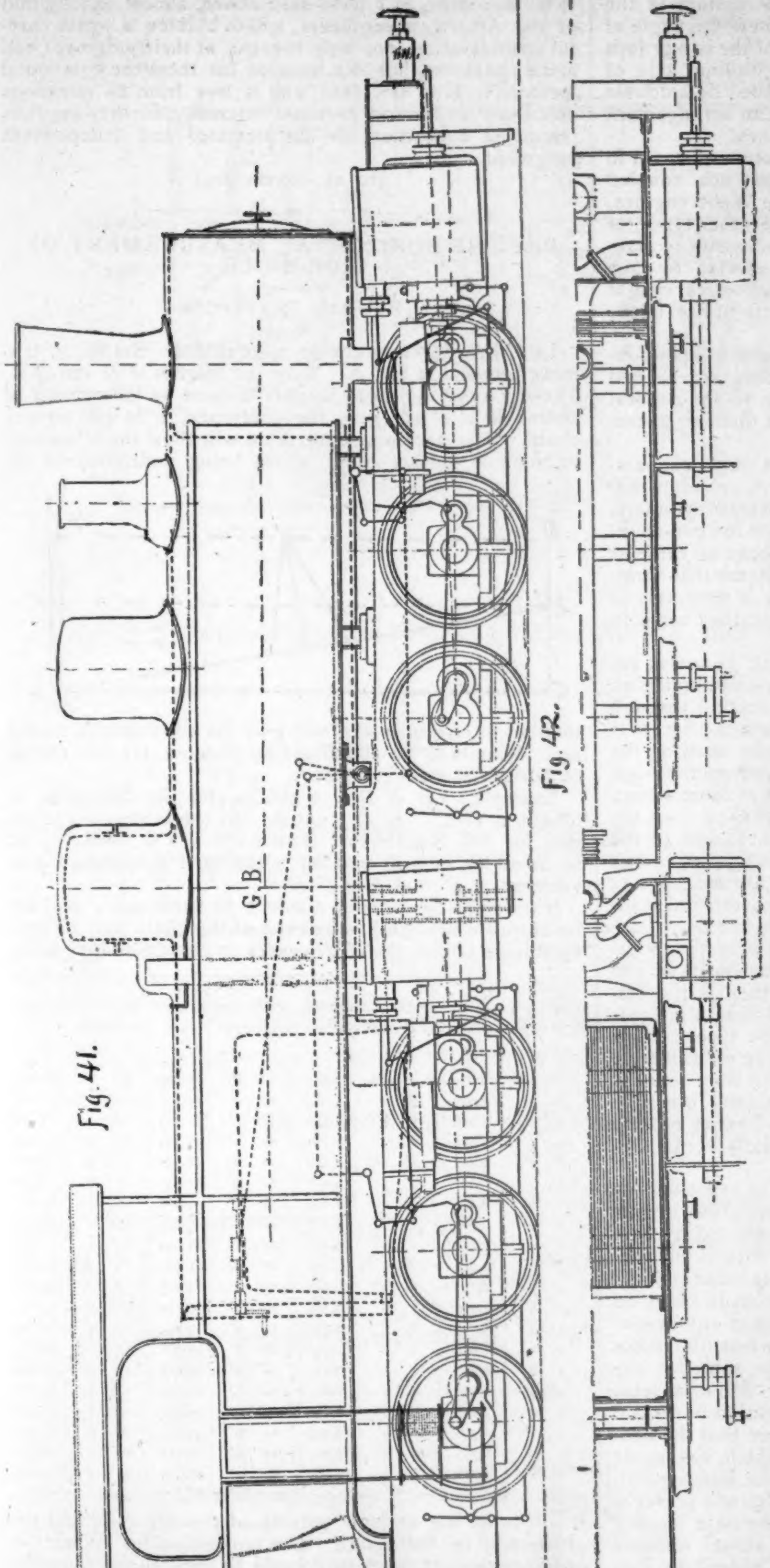


Fig. 41. Fig. 42.

FOUR-CYLINDER COMPOUND LOCOMOTIVE, GOTHARD RAILROAD.

spoken of those parts of the two-cylinder engines. The question of starting has less importance for the first, and it has generally been considered sufficient to put in a valve permitting direct steam from the boiler to be used in starting ; a safety-valve or reducing valve limits the pressure, which can thus be made one-half the boiler pressure. In some of the Decauville engines I have placed a starting valve, which allows both groups of cylinders to be worked as ordinary engines in case of necessity. In the heavy engine on the Gothard Railroad a similar apparatus has been put in, so that the engine can, when required, start heavy trains on the long grades of 2.6 per cent.

We have seen above that Mr. Webb had recently proposed to use an arrangement of this kind on his engines ; but this arrangement would only be justified by coupling the two groups of driving-wheels.

In the Baldwin engine the high-pressure cylinders carry a steam-pipe which joins their two extremities and a valve which, when opened at starting, admits the steam from the boiler through the small cylinders to act upon the large pistons, which only work in starting. It is possible that this arrangement has been a second thought, for it does not appear to us to conform very well with the method of connecting the two cylinders of each pair.

In compound engines with three or four cylinders, all the systems of valve gear used on the two-cylinder engine can be applied, and we shall not insist upon this point. We may say, however, that several engineers, Mr. Webb among others, think that it would be sufficient to give the low-pressure cylinders a fixed opening equivalent to 50 or 60 per cent. of the stroke, which would make it possible to use a single eccentric for each cylinder. This arrangement has been used on the locomotive *Jeanie Deans*, of the London & Northwestern. It is evident that in this case we must give up the use of the low-pressure cylinders in starting, and it remains to be seen whether the use of a single eccentric is good practice on a locomotive. This system, however, has been used for the low-pressure cylinder of the compound engine of the steamboat *Hirondelle*, running on the Seine ; this engine is run at 180 revolutions per minute.

In our compound articulated engines there is a special arrangement for connecting the reversing shafts of the two groups which are not parallel on curves. On curves of a very small radius, where consequently the axes of the two groups make a sharp angle, sometimes 6° and more, in the Decauville engine there is a shaft carrying in the center a universal joint, of which the left-hand part is coupled by a link with the forward reversing shaft, while the right-hand part is in the same

way coupled by a link with the reversing shaft of the rear group, and receives by another link the motion of the reversing lever. In the other engines, where the angle of the axes is much less, the reversing shafts of the two groups are joined by a link placed in the longitudinal axis of the engine, the ends of which are attached by a double joint to the levers of those shafts. This is an arrangement similar to that adopted in the Fairlie engines.

It is well to remark that for the distribution of steam in four-cylinder engines having two groups not coupled together, we must take account, as in the Webb engines, of a consideration which does not exist in other types, or at least in the same degree. This is the necessity of making for the maximum work the power exerted by each group of cylinders proportional to the adhesive weight upon the corresponding wheels, in order to utilize in the best way the weight of the machine.

In engines with three or four cylinders the pipes connecting the high and low-pressure cylinders are carried through the smoke-box or not, according to the general arrangement of the engine. Sometimes a distinct steam-pipe for each pair of cylinders is used.

In the articulated engines there is only a single connecting pipe, into which the two high-pressure cylinders discharge, and which leads to the low-pressure cylinders. What we have said of this connecting-pipe for two-cylinder engines can be applied as well to those of three or four cylinders; and it is hardly necessary to say that whatever may be the arrangement adopted, it is necessary to protect these pipes against cold wherever they come in contact with the exterior air.

In the accompanying illustrations, figs. 32, 33 and 34 are outline views, showing respectively a side elevation, a plan of the running gear and a front view and section through the smoke-box of one of the Decauville engines; fig. 35 is a longitudinal section on an enlarged scale, showing the steam-pipe connections, while fig. 36 is a perspective view of the same engine. This engine was one of those shown at the Exposition of 1889. Figs. 37 and 38 show the Central Swiss engine referred to above; figs. 39 and 40 the 35-ton engine for the Herault Railroad and figs. 41 and 42 the heavy 85-ton engine for the Gothard Railroad; fig. 43 shows one of the engines built for the Departmental Railroad, which is referred to above.

Having thus completed a summary review of the different types of compound locomotives so far built, we can submit a question: Is it necessary, or, rather, is it possible to derive from this examination any conclusion in favor of the superiority of one or other of these types? Is it possible that a definite general form will be established? Such a selection will justify those engineers who now say that they are waiting to apply the compound principle when practice shall have revealed such a distinct type by a process of selection from the models actually in use.

I do not believe it!

More than half a century of operation of railroads has not succeeded in securing the general adoption of one position for the cylinders of locomotives, and many years of practice have not established the superiority of one system of valve gear. It is the same with many other points; and each engineer of motive power continues to build his locomotives according to his personal tastes and preferences, without endeavoring to make them resemble those of his colleagues. It will probably be the same for the different types of compound locomotives. All, or at least almost all, of the forms find their justification in certain cases. At the same time we may suppose that the two-cylinder type, which was the first, and which has made the greatest actual advance, thanks to its comparative simplicity in construction and maintenance, will preserve that advance, since it can be applied, as we have already seen, to almost every case met with in actual railroad practice. The type with four cylinders placed in two separate groups for fast engines, or in tandem for heavy freight engines, will be preferred by those who attach importance to the objection raised to the want of symmetry of the two cylinders. Finally, the articulated engines have before them a wide field for lines of sharp curves and heavy grades; the secondary lines for which there is now a great demand.

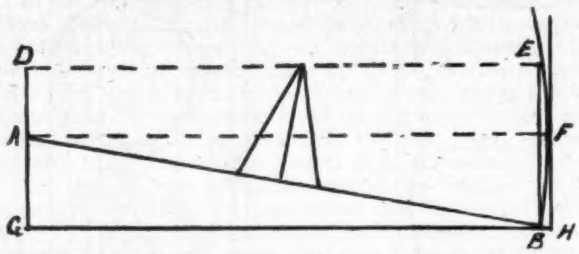
I do not believe that the future will change this view. It is, moreover, as I have said above, almost exactly that of the American engineers, whose opinion is worth careful consideration, not only because of their judgment and acute character, but also because for them the compound locomotive is a new field, and is free from all questions of *amour-propre* and personal interest, and they are thus placed in a position for disinterested and independent judgment.

(TO BE CONTINUED.)

PRECISE HORIZONTAL MEASUREMENT ON SIDE-HILLS.

By Seth Pratt, C.E.

Let $A\ B$ represent one or more chains. Set the instrument between A and B. Take the heights $A\ D$ and $B\ E$. The *difference* of these heights divided by the number of chains in $A\ B$ will give the difference in height for one chain. The accompanying table will show the allowance to be made for *one* chain, which being multiplied by the



number of chains in $A\ B$ will give the allowance in inches and decimals to be added to the distance for full chains of horizontal measurement.

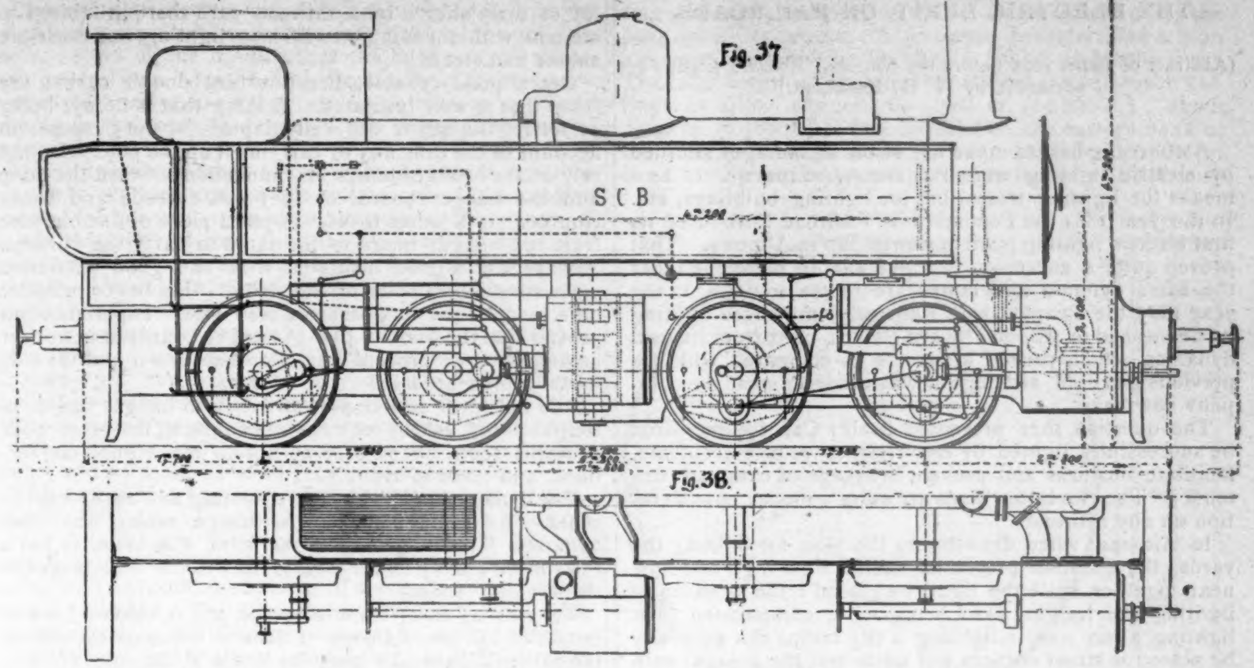
Example: Let $A\ B = 3$ chains and the difference in height $= 15$ ft. $15 \div 3 = 5$ ft. By the table, the correction for 5 ft. is 2.276 in. Now $2.276 \times 3 = 6.828 = 6\frac{5}{8}$ in. to be added to $A\ B$, making 3 chains of horizontal measurement $A\ B = A\ F = G\ H$.

If the slope for 1 chain distance be such that F will not be out of reach, the forward end of the chain may be held up till the plumb line $F\ H$ ceases to move forward, when

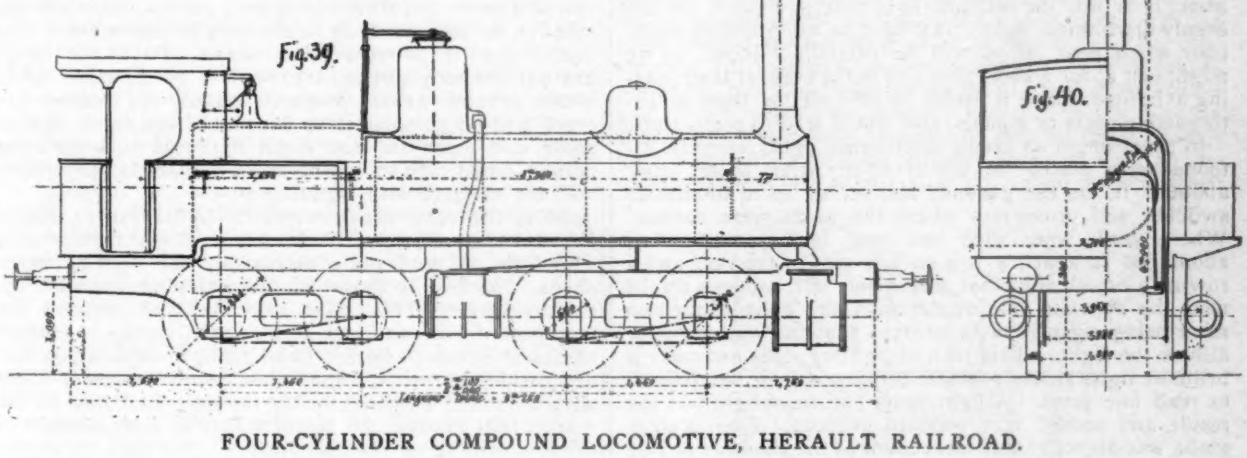
Difference in Height. Ft. In.	Correction. Inches.	Difference in Height. Ft. In.	Correction. Inches.	Difference in Height. Ft. In.	Correction. Inches.	Difference in Height. Ft. In.	Correction. Inches.
1′ 0″	0.090	6′ 0″	3.280	10′ 9″	10.576	15′ 6″	22.151
1′ 6″	0.205	6′ 3″	3.559	11′ 0″	11.077	15′ 9″	22.881
1′ 9″	0.278	6′ 6″	3.850	11′ 3″	11.590	16′ 0″	23.625
2′ 0″	0.361	6′ 9″	4.153	11′ 6″	12.115	16′ 3″	24.381
2′ 3″	0.460	7′ 0″	4.467	11′ 9″	12.652	16′ 6″	25.149
2′ 6″	0.568	7′ 3″	4.793	12′ 0″	13.201	16′ 9″	25.930
2′ 9″	0.688	7′ 6″	5.130	12′ 3″	13.762	17′ 0″	26.724
3′ 0″	0.812	7′ 9″	5.479	12′ 6″	14.334	17′ 3″	27.530
3′ 3″	0.961	8′ 0″	5.840	12′ 9″	14.919	17′ 6″	28.348
3′ 6″	1.113	8′ 3″	6.212	13′ 0″	15.516	17′ 9″	29.180
3′ 9″	1.279	8′ 6″	6.596	13′ 3″	16.124	18′ 0″	30.024
4′ 0″	1.456	8′ 9″	6.991	13′ 6″	16.745	18′ 3″	30.880
4′ 3″	1.644	9′ 0″	7.398	13′ 9″	17.378	18′ 6″	31.750
4′ 6″	1.843	9′ 3″	7.817	14′ 0″	18.023	18′ 9″	32.633
4′ 9″	2.054	9′ 6″	8.247	14′ 3″	18.681	19′ 0″	33.528
5′ 0″	2.276	9′ 9″	8.690	14′ 6″	19.350	19′ 3″	34.436
5′ 3″	2.510	10′ 0′	9.144	14′ 9″	20.032	19′ 6″	35.357
5′ 6″	2.755	10′ 3″	9.609	15′ 0″	20.726	19′ 9′	36.292
5′ 9″	3.101	10′ 6″	10.087	15′ 3″	21.432	20′ 0″	37.239

it will be at the extreme outside of the arc at F, and the chain will be horizontal. The correction for 1 chain in ordinary measurement may easily be determined *mentally* with reasonable accuracy by multiplying the square of the difference of level in feet, as estimated by the eye by $\frac{9}{100}$ for the correction in inches and decimals. Thus: For 6 ft. difference, $6 \times 6 \times .09 = 3.24$ inches. Error $= \frac{1}{25}$ inch. For less than 6 ft. the error is still less.

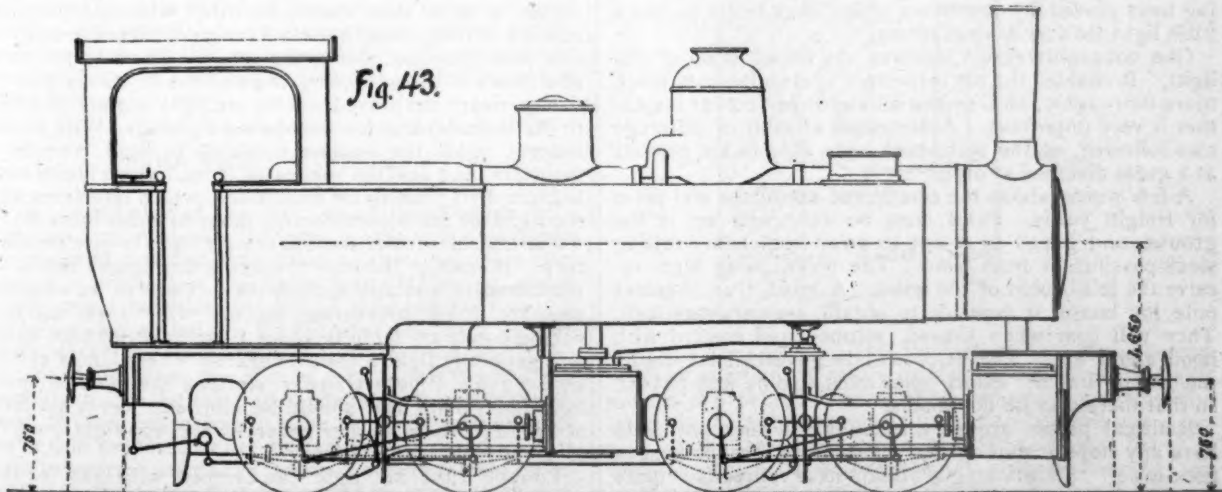
In the table the corrections are given in inches and decimals of an inch for differences from 1 ft. to 20 ft.



FOUR-CYLINDER COMPOUND LOCOMOTIVE, CENTRAL SWISS RAILROAD.



FOUR-CYLINDER COMPOUND LOCOMOTIVE, HERAULT RAILROAD.



FOUR-CYLINDER COMPOUND LOCOMOTIVE, DEPARTMENTAL RAILROADS.

THE ELECTRIC LIGHT ON RAILROADS.

(Abstract of paper read before the National Electric Light Association, by W. H. Markland.)

AMONG the first to make use of the advantages afforded by electric lighting were the steam railroads; not as a means for lighting trains, but for lighting buildings, etc. In the year 1881 the Pennsylvania Railroad introduced its first electric lighting plant in a new shop in Altoona. That proved quite a success. It might also be mentioned that the same dynamo and lamps are in use to-day. In the year 1885 the Pennsylvania Railroad commenced lighting its depot shed in Altoona by arc electric light from its own dynamos, which proved a success as compared with the previous gas light, although it was crude to what the company now has.

The question then presented itself: Can freight yards be successfully lighted by electricity to reduce accidents, facilitate business and prevent breakage of cars and contents? The two latter items are quite a money consideration on any railroad.

In Altoona, when drawing up the plan for lighting the yards, the question presented itself: How high and how near together shall the lights be placed? the problem of lighting the freight yard being more complicated than lighting a city; as in lighting a city lamps can generally be placed at street corners and quite low, the general public being not over particular; so that under or near the lamp the light is quite brilliant, but in the space between lamps there is less brilliancy.

For lighting where engineers and trainmen have to work, it is not the brilliant light that is wanted, but the evenly distributed light. If a light be too brilliant, trainmen when near lamps will be partially blinded, as we might call it, for a short time; so in the event of their leaving a lighted space it would be difficult for them to distinguish objects or signals, and would lead to complaints.

In order to get an evenly distributed light, lamps in Altoona were placed on top of 65-ft. poles, these being about 8 ft. in the ground, and set so as to illuminate switches and crossovers where the yards were narrow. Where yards were wide and long, lamps were placed about 600 ft. apart, a row on one side of the yard and a row in a broad alley that was wisely left between tracks near the opposite side of the yard, the lights of the two rows being zig-zagged to prevent shadows and to better diffuse the light. This plan of lighting does not make a brilliant light at any point, it being possible, but difficult to read fine print. A light more like moonlight was the result, and proved very good in practice. Even a clear globe was objectionable on account of the shadows of side arms. A lower-half ground globe was preferable, it having been proved by experience that it was better to lose a little light than to have shadows.

One noticeable result followed the introduction of this light. It enabled the car inspectors to examine cars much more thoroughly, and, as you all know, perfect car inspection is very important. A decreased amount of pilferage also followed, as the watchmen were able to see persons at a great distance at night.

A few words about the erection of arc lamps and poles for freight yards. Poles must be very well set in the ground, and guyed so as not to sway from heavy rolling stock passing, or from wind. The poles, being high, receive the full benefit of the wind. A good, true chestnut pole for lamps, if possible to obtain, answers very well. They will cost when shaved, stepped and erected with hood about $35. The price will be governed largely by the cost of timber. Short poles must also be well put up, so that there may be no breaks.

Railroad people are very exacting; it does not do to have any stops or shut-downs. The lamps must be kept in good order. Maintaining arc lamps near railroads is quite different from maintaining lamps in most stores. If there is a poorly insulated part in the lamp, the soot will soon find a path for the current across the poor insulation, and out goes your lamp. Your cut-out contacts will corrode very fast. When it comes to your rods, expect to have a lot of dirty ones. In a railroad yard there are things to contend with not common with most lighting, and those are smoke and steam.

Get a good reliable, direct-current double carbon arc lamp that is well insulated. A lamp that is heavy, bulky or having liquids is not well adapted for the purpose, on account of the difficulty of carrying it up the pole. Do not rely on the hooks of lamps for connection between the lamp and the hanger board, or they will corrode and cause trouble. It is better to always put a piece of flexible wire from the hanger board to the lamp to carry the current. Always use a good insulated wire and good insulators when running up poles or side arms. It is better to splice on a piece of the very best insulated wire. Experience has proved that the wooden part of hanger boards is better for having some waterproof insulation between it and the side irons to prevent leaks.

I do not favor double-pole switches on hanger boards in freight yards, as they require extra contacts, the brass work of which soon corrodes so as not to make good connections, and leads to trouble.

The dynamo should be self-regulating and easily kept in order. As there may be 100 lamps, taking, say, two dynamos for all lighting at one point, it is better to put a little more money into dynamos than to pay high wages to the dynamo tender.

Keep as far away from telegraph and telephone lines as possible. If any damage is done to either of the above, the railroad generally gets the worst of the suit. If you are going to hire the lights from a central station, see that they give you good work, and make a contract with a rebate and fine for the time lights are out.

If you once properly put electric lights in a freight yard, you will never get them out again; the trainmen will not stand it, as they would be in the dark in more senses than one if the lights were taken away. But if the lights are not properly put in, say, on low poles, under 40 ft. above ground, or not properly spaced, the chances are there will be complaints on account of too much light at some one point and too much darkness at some other point. Great care should be taken to place lamps so they will not interfere with signals.

As to the other uses for electric lights for railroads, I do not know that there is much out of the regular run. The light is used quite extensively for lighting depot sheds, where it is more economical than gas and decidedly better. This class of installation requires the very best of work and insulation, as the smoke and steam nuisance enters in here. Even though depot sheds are dry inside, porcelain knobs should not be used, glass with a double petticoat being the only kind now on the market that answers the requirements well, on account of the soot settling on the insulators.

It does not do to have a depot in darkness; for that reason a depot shed should be wired with two complete circuits, having every alternate lamp connected to one circuit and the remainder to the other. Then, in the event of a break in the wire, only one-half the lights are out.

Experience has proved that the arc light is much superior to the incandescent for depot shed lighting. With incandescent lights the necessary volume of light is costly to maintain, and also the globes of incandescent lamps soon become dirty from steam and smoke, which interferes with the light, or takes considerable labor to clean them off.

For freight transfer stations the arc light is very satisfactory. It enables the men to quickly distinguish marks on merchandise, and also enables the foremen to see what the men are doing, preventing loafing. One 2,000 nominal candle-power arc lamp to about 1,500 sq. ft. of floor space will generally light a transfer station where lamps can be zig-zagged. Where transfer stations are narrow more light per square foot should be allowed. On a platform about 10 ft. wide, as they generally are, one light every 60 ft. gives good illumination.

I doubt if the arc light can compete with gas for this purpose as far as cost is concerned, taking transfer stations as they are generally lighted by gas and as they should be lighted by arc lights. Yet I believe, taking the amount saved in labor and from pilferage, that the electric lights more than pay for themselves.

I hear that an electric headlight has lately been brought out which it is claimed will illuminate a track for a mile or more. I am of the opinion that the light will not come into general use. In the first place, a light for this purpose should not be too strong, or it will blind an engineer coming in the opposite direction, this being a serious objection.

If any inventor wishes to get up an electric locomotive headlight, let him confine himself to one of low candle-power—the present ones are about 20-candle-power. I do not think one of over 100 candle-power will be in demand until railroads are illuminated from one end to the other by electric light, which will be the case in the future, and then the headlight will not be required.

These points are necessary for an electric headlight: First, and all important, reliability; second, simplicity. Economy you can leave out. If you can get 50 per cent. of what can be attained in a station, it will do. One thing must be borne in mind—engineers are not electricians. Thus a dynamo and lamp must be as simple as the air-brake, and no more liable to get out of order.

The experiment has been tried of lighting cars by electricity. While it has proved a success in some cases, as far as convenience is concerned, financially it has not proved a success. Electric lighting of trains is a luxury to-day, and will continue to be until some more economical plan is invented. The advance that is being made with the use of gas as an illuminant for cars is leaving electricity behind. From the best information I can get, it costs 50 cents per hour to light a car by electricity from storage batteries, against 5 cents per hour from carburetted air.

The electric light is used to some extent by different railroads for lighting wrecks or any construction work that requires night work. For this purpose the Pennsylvania Railroad and the Cumberland Valley road have a car fitted up with boiler, dynamo, engine, water tanks and coal bunker, and all the tools necessary for a central station. With a car of this description, quick work in getting lamps in place is all important. In one case, after the Johnstown flood, I, with the help of four men and the engineer, put up six arc lamps, put up the poles for the lamps (which were designed for the purpose and carried on the car), ran the wire, coupled up the lamps, and had the lamps going in 35 minutes from the time we, with the car, lamps, poles and wire, arrived on the ground. The lights were distributed some distance, one being about one-third of a mile away. I doubt if construction work was ever done quicker.

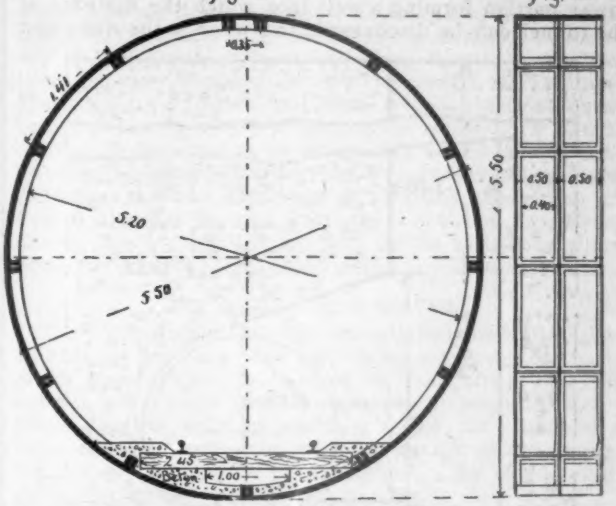
To give an idea of what the Pennsylvania Railroad Company thinks of the electric light, I might say that its new Juniata shops at Altoona, having about 100,000 sq. ft. of floor space, are lighted entirely by the electric light; there is not a pipe for illuminating gas in any of the buildings. All the traveling cranes are run by electricity.

The Pennsylvania Railroad Company believes that good electric work pays. I doubt if any station, central or isolated, has more reliable or better designed appliances or more artistic work than can be found at the Juniata shops of that company.

THE SEINE TUNNEL.

The construction of the new line of the Western Railroad from Port Audemer to Havre, which was intended to give a second railroad connection to that important city, required a crossing of the Seine near Quillebœuf, which was the most troublesome part of the proposed line. It was impossible to build a bridge over the river at that point without seriously obstructing navigation, and as on one side of the river the alluvial formation extended to a great depth, the building of an ordinary masonry tunnel would be very expensive. Under these circumstances it was at first proposed to use a steam ferry upon which cars could be carried across the river; but upon further investigation it was found that this would be much more difficult and expensive than was at first supposed, owing to the constantly shifting nature of the river banks, the great variations in the level of the river and the difficulty of making the crossing with a large ferryboat at certain stages of wind and tide, which would be sure to carry the boat out of its course. After some consideration a plan has been prepared for building a tunnel under the river. The total length of this tunnel between the approach cuttings at either end will be 4,500 m. (14,760 ft.); about 2,000 m. (6,560 ft.) of this distance on the eastern bank of the river is through solid ground, composed chiefly of chalk of different composition, and in this part an ordinary

Fig. 1. Fig. 2.



masonry tunnel can be built without difficulty and without unusual expense. For the remaining 2,500 m. (8,200 ft.), which passes under the bed of the river and through the great alluvial deposit west of it, a tunnel will be constructed with cast-iron lining somewhat on the same principle which has been adopted for the Hudson River tunnel and for the recently constructed City and South London Railroad. The tunnel, which will only be large enough for a single track, will be circular in form, with an external diameter of 5.50 m. (18.04 ft.), a clear internal space

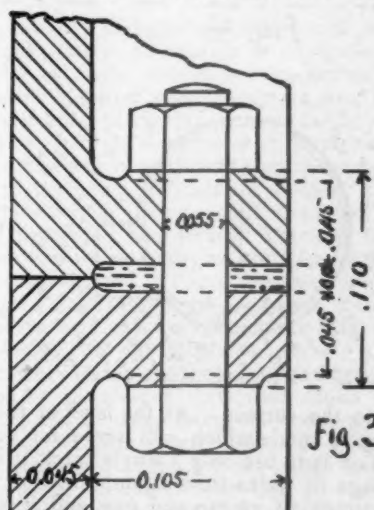


Fig. 3.

of 5.20 m. (17.06 ft.). The ties will be laid at the bottom in a bed of béton, in which, under the center of the track, a drain is provided to carry off water which may accumulate. In the accompanying illustration fig. 1 shows a section of the cast-iron tunnel, the dimensions being in meters; fig. 2 is a longitudinal section showing two lengths of the cast-iron rings of which the tunnel lining is composed; fig. 3 shows a joint in the cast-iron ring on a larger scale; fig. 4 shows one of the ventilating shafts, and fig. 5 a section at one of the recesses made for the workmen.

The tunnel will have from either end a descending grade of about 45 ft. to the mile, while in the center under the bed of the river the grade will be level for a distance of 560 m. (1,836.8 ft.). At each end of this level section a shaft will be sunk for drainage and ventilation, and the arrangement of one of these shafts is shown in fig. 4. The shaft will be lined with cast-iron segments similar to those in use in the tunnel, and will be 3 m. (9.84 ft.) in diameter, descending below the level of the tunnel, the lower portion forming a well into which the drainage of the tunnel can be discharged, and whence the water can

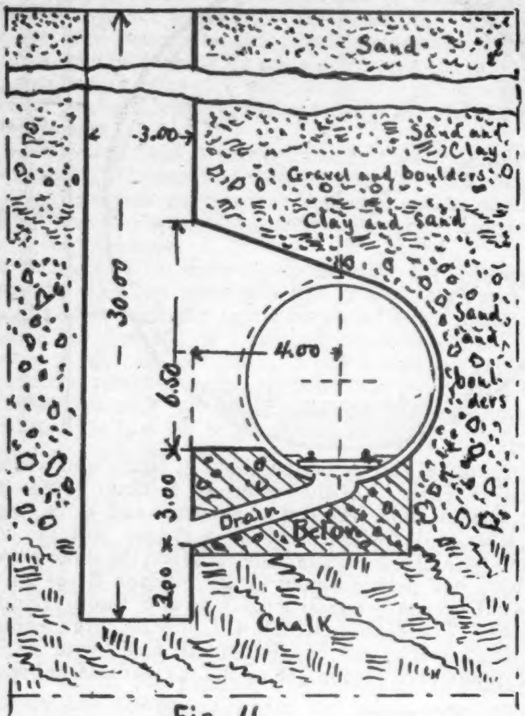


Fig. 4.

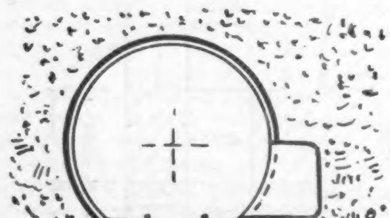


Fig. 5.

be pumped to the surface. At the level of the tunnel a large opening is made which will serve for ventilation. As the intention is to use only a single track, it is thought that the passage of trains from either direction will serve to clear the tunnel of smoke and gas, and it is also proposed to try a car of peculiar construction, having a circular front nearly filling the entire diameter, for this purpose also. If necessary, however, a system of artificial ventilation can be adopted.

As shown in figs. 1, 2 and 3, the tunnel lining will be composed of cast-iron rings 0.50 m. (1.64 ft.) in length, each ring being composed in its turn of 12 cast-iron plates, all of the same dimensions, and one smaller, or key-plate, placed at the top of the ring. The segments and the rings themselves will be joined together by bolts, as shown in fig. 3, with proper packing for the joints. At regular distances niches will be placed in which the men employed in the tunnel can stand during the passage of trains; one of these is shown in fig. 5.

The method employed in driving the tunnel will be substantially the same as what is known in England as the Greathead process, a shield being worked ahead of the tunnel under the protection of which the sand is excavated and the iron rings placed in position. The head or shield can be forced forward by hydraulic pressure, and the excavation can proceed steadily as it advances. With an iron lining it is necessary to take out very little more material than the space actually filled by the tunnel. In all cases it is proposed to protect the outside of the iron casting by a coat of hydraulic cement, which will be forced in as each ring is placed in position. This cement will, it is believed, protect the iron from rusting.

The cost of this metallic tunnel is very much less than of a masonry tunnel, and at the same time it can be carried out in places where the nature of the soil would render the excavation required for a masonry tunnel enormously expensive, or even impossible.

OUR NAVY IN TIME OF PEACE.

By Lieutenant Henry H. Barroll, U. S. N.

(Concluded from page 174.)

THE NAVAL OBSERVATORY.

The Naval Observatory has for the greater part of its field of work scientific research into the realms of astronomy—a duty that the civilized world in all ages owes to future generations.

There is, however, much astronomical work done here that directly advances the interests of those engaged in commercial pursuits. The times of transit of various heavenly bodies are here computed, star tables arranged and published, signals sent each day to all parts of the United States, and time-balls dropped at exact meridian time, by electricity, that our clocks and chronometers may always be exactly regulated to the time of our several meridians.

It would be impracticable in the limits of this article to attempt to describe the various problems that enter into the study of the heavenly bodies and their motions. Some of these are intricate and almost hopeless problems; yet the final solution of these would bring us nearer to a knowledge of those laws that govern the universe; and there are none of us who do not realize that such work is of benefit to mankind.

Many of these investigations, such as the examination of the variable and recurring spots upon the sun, the flickering waves of the Aurora, and the effect of these phenomena upon the variation of the magnetic needle, are in the immediate advancement of civil interests.

The most important part of the astronomer's work consists, not in the taking of the observations, but in the collating, arranging and publishing in proper form of the results thus obtained.

In late years two new sciences have been called into use to assist astronomical research—Photography and Spectroscopic Analysis. Investigation of the heavenly bodies by the aid of these methods has been attended with good results. Their use in connection with astronomy has necessitated the invention of several new words, among which is Astro-photography, the title of one of the new methods of investigation.

Astro-photography has been largely used in recent observations of eclipses, and of the transit of Venus. Of all astronomical phenomena, the transit of the planet Venus probably contains for the astronomer the greatest amount of interest. It is from this transit that we are enabled to estimate, even as approximately as we now do, the distance from the earth to the sun, and to the various other planets of our solar system.

There are but two of the planets whose orbits lie between the earth and the sun. Mercury, nearest to the sun, travels in a path much closer to that body than to the earth. Observations of its transit, therefore, cannot be relied upon for the determination of distance, as a small angle would have to be used in order to determine a larger one—always a source of probable error.

In the case of Venus, however, its orbit being nearer to the earth than to the sun, the reverse of these conditions

obtains, while the planet itself being larger, the observation of its passage across the sun's disk is more practicable.

A transit of Venus, then, furnishes a means of procuring from the angular positions of the planet at the first, middle and last points of transit data from which, by a ratio of angles, we can approximately determine the distance of our earth from the sun ; and later, by the employment of this distance so determined, can also find that of the other planets.

Successive transits of Venus occur at intervals of about eight years ; and these times of transit are now looked forward to with great interest, since each recurrence of the phenomenon may give a little further insight into that unfathomable space that we call the universe.

It is of importance that the observations of the transit be taken from points widely separated on the earth's surface, that the lines of sight obtained may be as diverse as possible. Under the direction of the Naval Observatory, parties are generally sent to some foreign quarter of the globe for the purpose of observing this transit.

For many years the observation of the transit of Venus has been made, the earliest of which we have any record being that made in 1639 by Jeremiah Horrocks, a youthful English astronomer.

The observations made in 1761 and 1769 were attended with special success. The mean of the greatest and least distances of the sun from the earth, as determined by the observations of those years, was placed at about 96,000,000 miles. Later observations have tended to reduce this distance, which is now believed to be between 91,000,000 and 92,000,000 miles.

It may seem that there is not much accuracy reached when the distance sought after is still in doubt to the extent of a million of miles ; but it must be remembered that this is a result of a start from utter ignorance, and that the measurement has been made while the earth has been plunging along in her orbit at the rate of 19 miles a second.

LONGITUDES BY ELECTRICITY.

Much danger to navigation results from the fact that many well-known points and headlands were in former times erroneously placed upon charts, owing to the wrong determinations of longitude. The determination of latitude is a simple problem, and is not so liable to error. The determination of the longitude of a place, however, depends entirely upon the accuracy of the time-piece employed in making the calculation ; and, therefore, many of the earlier established points were later found to be sadly in fault as regarded their geographical positions.

The manufacture of the chronometer, which gave to its inventor a handsome prize from the Royal Society of London, was the turning point in the establishment of correct geographical position. But it is in still later years that by the use of the electric cable, and its companion, the chronograph or time-marker, that we are enabled to discover the slightest differences in position of longitude.

The net-work of telegraphic cables which now encircles the earth facilitates the accurate determination of the longitude of some one point in each great geographical section, from which as an origin the entire systems of surveys of that country may be corrected.

As a matter of course this accurate determination by the use of the electric cable will greatly change the positions of some of those points located in ancient times by less exact methods. This error in the absolute position of capes, bays, shoals, etc., has no doubt been responsible for many of the disasters that have occurred in navigation ; and the Hydrographic Office has, for some years past, been sending parties to different parts of the world, making exact determinations of the latitudes and longitudes of points not accurately established.

It is the custom to determine closely the geographical position of some important point in a country, and then from the application of the error discovered in the former position of this point, as placed upon the chart, the entire coast-line of that country can be corrected.

In the determination of the longitude of the observatory at Cambridge, Mass., great care was exercised to arrive at its exact geographical position. It is stated that, in order to leave no room for error in this position, 50 chronometers were used in its determination ; and these were carried between Greenwich and Cambridge a number of times, the error of each instrument being cancelled by its return to the Greenwich Observatory, while the system gave not only a mean of the 50 chronometers, but a mean of a number of observations with each instrument.

Notwithstanding this attempt to obtain accuracy, and which was no doubt the most accurate way in which, in that day, the observation could have been made, the later use of the electric current, in making longitude observations between Washington and Greenwich, showed that Washington, as determined from the longitude of Cambridge as an origin, was in error to the extent of 18" of arc.

From Washington as an origin, this work has been continued southward throughout the West Indies and to South America—the true meridians of Havana, San Juan de Puerto Rico, St. Thomas, Port of Spain, Colon, Vera Cruz, Rio de Janeiro, etc., having been by the assistance of the ocean cables accurately established upon all charts.

THE LIGHT-HOUSE SERVICE.

The looking out for the numerous light-houses and lighted beacons that have been established all along the coasts of the United States is a task of such magnitude that it is necessary to divide our territory into 16 separate light-house districts, each of which is under the charge of a naval officer as Inspector, who has charge of the supplying and the keeping in position of all of the aids to navigation in that district.

The First, to the Eighth Districts, inclusive, cover the Atlantic and Gulf coasts ; the Ninth, Tenth and Eleventh embrace the Northern Lakes ; the Twelfth and Thirteenth the coasts of California, Oregon and Washington, and the Fourteenth, Fifteenth and Sixteenth the Mississippi, the Ohio and their tributaries.

There are in existence in the whole world about 8,000 light-houses and lighted beacons. Of this number, over 900, or considerably more than one-tenth of the entire number, are owned and kept in order by the United States.

But the number of light-houses is small in comparison with the multitude of other aids to navigation, which are also of fully as much importance to navigators. There are thousands of buoys which no doubt seem to the landsman to have been placed at random in the various channels ; and yet it is of the utmost importance that each of these is kept as nearly as possible in its specified place.

Owing to the great difficulty in keeping some of these buoys in their proper places, small steam vessels are kept constantly patrolling the several districts and replacing those buoys that have dragged and repairing others that may have been injured. There are thus employed in the Light-house Establishment 30 steamers, known as light-house tenders, and these as a general rule are kept constantly at work. In our Northern ports it sometimes becomes necessary to remove the numerous buoys during the winter months, to prevent their destruction by masses of floating ice ; and in these cases the buoys are replaced as soon as spring weather assures their not being destroyed.

The importance of keeping these buoys in their rightful positions may be seen in the fact that all of the sea-board States have passed laws in regard to their being either accidentally or willfully removed from their proper positions. The penalty for even accidentally removing a buoy, or other authorized aid to navigation, and not immediately giving notice of the same to the proper authorities, is fixed, in the several States, at from $200 to $300 ; while there is a penalty of $50 for even anchoring on the line by which a range of lights would be obstructed.

The supplying of the various light-houses with provisions, oil, fuel, etc., for the running of the large lanterns, steam fog-horns and electric lights is a matter of the greatest importance ; and in the case of those light-houses marking outlying shoals or rocks is often attended with danger and difficulty.

As an example of the number of these aids to navigation, and the amount of work that their care must entail upon those having them in charge, may be cited the Fifth, or

"Baltimore" District, in which there are 110 light-houses and about 1,200 buoys, each of which can generally be depended upon as being in its proper position.

The Light-house Board annually publishes a newly corrected list of all lights on the coasts of the United States. There are also published for each district (in separate pamphlets) the list of the buoys in that district, together with an account of the position which each buoy occupies, etc., and these enable a navigator, when visiting this section for the first time, to avoid the many dangers that they are placed to indicate.

Thousands of these books are each year distributed, free of charge, to persons interested in maritime affairs. In each of these buoy books is printed a notice, requesting that any master of a vessel finding one of these aids to navigation out of place, or any light failing to properly illuminate its intended space, will give notice of the same to the Light-house Board. In answer to this, hundreds of items of information of this nature are being constantly sent to the Inspectors, and thus the channels and coasts are kept comparatively well marked.

INFORMATION FROM ABROAD.

Another important class of duty assigned to Naval Officers, and which is of direct advantage to manufacturers and shippers, is that of collecting information with regard to foreign ports. Especially is this of benefit in the case of those ports which are seldom visited, and which are but slightly known.

On every vessel in commission there is one officer who, in addition to his regular drill-duties and watch-keeping, is required to collect and forward to the United States such information as he can obtain with regard to the manners and customs of the people, their exports, imports, manufactures, custom and harbor dues, the depth of water, and facilities of access, etc., at all of the ports visited by this vessel.

The information that is thus being constantly forwarded to Washington finally comes before the citizen, but in many cases, possibly, through some channel that does not indicate the means by which it was collected.

It is not practicable in this article to attempt to describe the varied duties of those officers attached to the Navy Yards, in the equipment, navigation, construction, engineering and ordnance departments, or those assigned to duty in the manufacture and inspection of guns, projectiles and explosives, steel inspection, etc., yet all of this work is of the highest importance. It is not altogether to the man who fires the cannon that the credit of its splendid execution is due. We must not overlook the years of patient study, the result of which has been the evolution of the present Navy rifle, the 6-in. pattern of which recently demolished the English armor-plates designed to withstand the shot of a 10-in. gun.

In concluding this subject, however, it may not be amiss to take a general retrospection of what has been said with regard to naval duties. The introduction of the modern steel cruiser, to replace the obsolete wooden vessel, has necessitated numerous and varied changes; and our Navy is now in a state of transition from its condition in 1865 to an efficiency approaching that of foreign navies at the present time.

It has only been in the ships and their armament that the U. S. Navy has, at any time in this period, been behind foreign powers. It is unhesitatingly asserted that so far as the *personnel* of our navy is concerned, it has always favorably compared with those of foreign powers. Considering the material from which we have frequently been compelled to draw for crews for American men-of-war, the manner in which these men have been drilled and held to discipline has time and again called forth the highest praise from foreign naval officers, who recognize the difficulties with which American naval officers have had to contend.

The greatest care should be taken in the selection and education of those officers and seamen who are in the future to man our fighting ships. Until recently our vessels, although officered from the native-born population, have been almost entirely manned by seamen of foreign birth.

It is not fair to stigmatize these men simply because of the fact that they are foreigners. They have, as a general rule, fairly executed their contracts undertaken with the Government. They entered the service to obtain a certain amount of money and to do a certain amount of work; and in the majority of cases they have done what they contracted to do—either voluntarily, or else under the pressure that can always be brought upon them by judiciously applied punishment.

But while work and obedience can always be obtained by the fear of double irons or a term in Wethersfield, patriotism cannot in the same way be instilled into a man's heart; and, therefore, the best results will necessarily be obtained from enlisting only Americans to fight for the American flag.

It is but natural that the men picked up here and there all over the world, and who in many cases may have recently deserted or been discharged from vessels of other nationalities, will not man our ships as effectively as those who have the nation's welfare at heart, in addition to their own pecuniary interests.

In many cases such men would find aboard of an American man-of-war a comfortable birth, safe from detection and secure against the severe treatment and harder work of the merchant service, owing to the mild discipline and laws in his favor that prevail aboard of a Government vessel.

Seamen are proverbial growlers—especially those of the old school, who have been taught to consider this trait as one of their prerogatives—yet it becomes irksome to those who fully understand the true state of affairs to hear a foreign beachcomber (after having gotten his stomach well filled and his nakedness well clothed in the United States Navy) inveigh against the severe discipline and the hard work that prevails in the Government service, as contrasted with that ease and comfort he formerly enjoyed in the merchant service.

The persons most desirable for crews of modern men-of-war are, first of all, Americans—men who wish to find a home in the service. The navy is the last place in the world in which to seek a life of ease and idleness; nor should it be made an asylum for criminals fleeing from justice. But the man who enters the naval service with the object of making this his vocation in life, and who exerts himself to learn thoroughly the profession he has chosen, whether as officer or seaman, will find it a pleasant life. Strict obedience is demanded, and will be enforced; and whether he proposes to enter as cadet or as apprentice, if he cannot first make up his mind that he is going to be subordinate to his superiors, he had better remain outside.

It is not mere food for powder that is desired. The typical old salt—the American man-of-war's-man of romance—had many fine points of character. In the day of sailing vessels there was not his superior on the face of the earth; but he has now about disappeared, and we find in his place a man of many parts—a curious conglomeration of boatman, electrician, artilleryman, soldier, sailor and engineer, and whom it would be difficult to classify under any one of these lines of duty.

The method of carrying on warfare has become a perfect system of machinery; and there has, perforce, been a radical departure from former methods. For example, the boarding of a modern vessel of war, when properly manned and officered, is, in this day of machine guns, as utterly impossible as would be the capture of one of our fast modern cruisers by the swift sailing frigate of 1812.

On the other hand, while machine guns and a "good look-out" give immunity from being boarded, the various types of stationary and movable torpedoes present another source of destruction of which our predecessors could not avail themselves, and against which they did not have to guard.

Torpedoes are, in their turn, rendered partly ineffective by constructing vessels with double bottoms and with numerous water-tight compartments; by the use of crinoline on the vessel's sides; by wire nettings and torpedo booms, etc.; while revolving search-lights serve to place the dangerous torpedo-boat at once under the fire of rapid-firing and machine guns.

The effect of the many recent changes in the methods of naval warfare cannot be accurately measured until two great maritime nations are brought into actual combat. Until then it is all a matter of conjecture. It is not practicable to produce a war in order to try the effect of smokeless powder, submarine boats and dirigible balloons. It is fair, however, to suppose that the next great conflict between maritime nations will, from the employment of these and other unproved agencies, add wondrously to the naval history of our times.

The most probable effect will be to require greater precaution, slower advance into action, less dash and greater precision of movement when once engaged. In this day, more than ever, will the man with the coolest head win the victory.

The ships, guns, motive power, even the men themselves, are mere parts of a gigantic machine, which can properly wield its immense force only when all parts are in thorough order and working in complete accord. It is needless, therefore, to say that Victory is most likely to perch upon the banners of that nation who has provided her navy with the best tools.

It is the knowledge of this absolute necessity for the proper class of vessels that leads so many naval men to raise their voices in favor of battle-ships.

It is generally supposed by those only partly acquainted with the subject, that when a naval officer advocates an increase in our force of naval vessels, he has some ulterior expectation of promotion on account of this increase. This is a mistake. He is actuated by the thought that it is a duty that he, as a professional naval man, owes to the country that has educated him; and, of course, also, by his desire to be the better protected against the ignominy of defeat.

It is a mistake to suppose that an increase of promotion will necessarily follow from an increase in the number of ships. The number of officers allowed in each grade is fixed by statute, and remains the same, until altered by a law of Congress, no matter whether our navy be composed of wooden gun-boats or steel-clad battleships; and an increase of the number of vessels allowed to the navy simply means a greater amount of duty for the same rank and pay.

When looked at in this light, it must excite respect to see how persistently the naval officer places to the front that which, although contrary to his mere personal comfort, he knows to be for the best interests of the country.

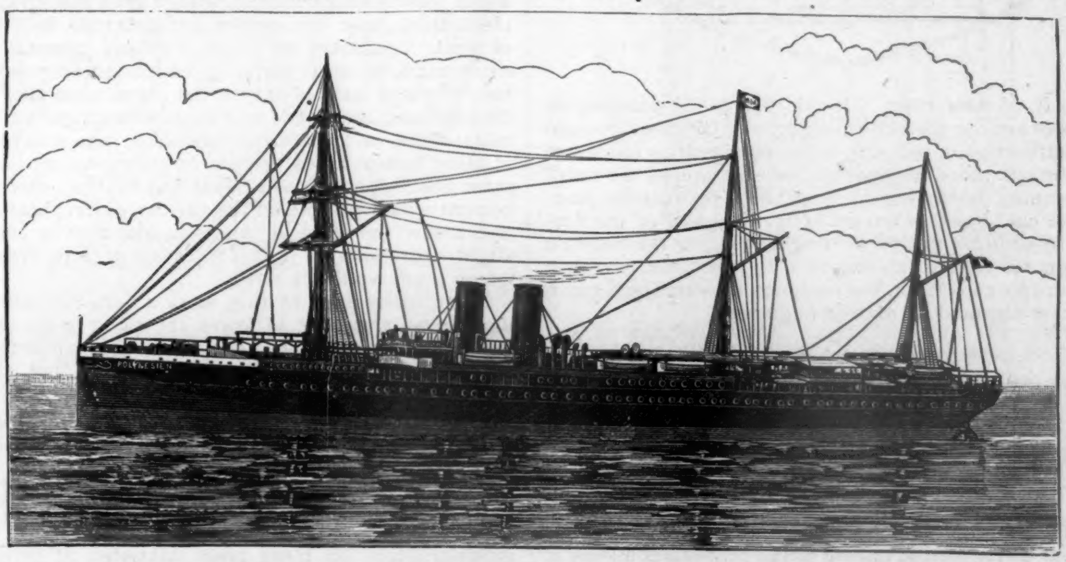
In forming an opinion of the amount of work that any class of people are accustomed to perform, we must be careful not to make our estimate from observations taken while these people are enjoying a holiday. It would be as reasonable to judge of the industry of the agricultural class from an inspection of a party of farmers at a county fair, as it would to form our opinion of the duties of a sailor, and use as a criterion the time he is ashore for recreation. There is not a busier class of people in our country than the officers and seamen who man our naval vessels.

It has been impracticable in this series of articles to do more than briefly outline the multifarious duties assigned to every one in the naval service, afloat and ashore; but it is hoped that these have been sufficiently described to disprove the oft-repeated assertion that our officers and seamen form a part of the "Leisure Class" of the United States.

A NEW FRENCH STEAMER.

THE accompanying illustration, for which we are indebted to the *American Shipbuilder*, shows the steamer *Polynesien*, recently completed at La Ciotat, near Marseilles, France, for the Compagnie des Messageries Maritimes and intended for the line between Marseilles and Australian ports. The *Polynesien* is the third of three similar vessels built for this line, the other two being already in service.

The principal dimensions of this ship are: Length, 502 ft.; beam, 59 ft. 6 in.; depth, 44 ft.; mean draft, 24 ft.; displacement, 8,638 tons. They are fitted with excellent accommodations for passengers and have plenty of room for cargo.



STEAMER "POLYNESIEN," COMPAGNIE DES MESSAGERIES MARITIMES.

The engines are of the triple-expansion type, with cylinders 44 in., 67 in., and 106 in. in diameter, by 54 in. stroke. With a piston pressure of 180 lbs. and 82 revolutions per minute, these engines developed 7,650 H.P. The speed in regular service is 18 knots an hour, which is unusually high for ships employed in Australian and East Indian service, as there are very few lines—outside of those between Liverpool and New York—where a speed of 15 knots an hour is exceeded.

The peculiarity of these ships is in the fact that steam on them is made entirely in Belleville boilers. This type of tubulous boiler was illustrated in the JOURNAL for July, 1890, page 321. In these ships the boilers are set in two lines placed back to back, as shown in the transverse section of the ship given in fig. 2. The *Polynesien* has 20 in all, placed in two groups of 10 each, one smoke-stack serving for each group. They are built to carry a working pressure of 200 lbs., but it could easily be increased if desired, so that the quadruple expansion, with 240 lbs. initial piston pressure, could very easily be used if desired. In the *Australien* and the *Tasmanien*, the sister ships of the one illustrated, several voyages have been made, and the working of the boilers has been admirable. Some time ago also the *Ortegal*, a freight steamer owned by the same Company and used on their La Plata line, was fitted with

Belleville boilers, and it was found that with an additional steaming power of about 40 per cent. the weight was not increased over that of the Scotch boilers.

In the *Polynesien* the total grate surface of the 20 boilers is 633 sq. ft., and the total heating surface 23,000 sq. ft. The entire floor space occupied, including a cross passage at each end of the boiler room and one between the two groups of boilers and the firing space at the outside, is 84 ft. 9 in. fore-and-aft by 29 ft. 6 in. athwartship, so that the boilers, fire-rooms and passages use about

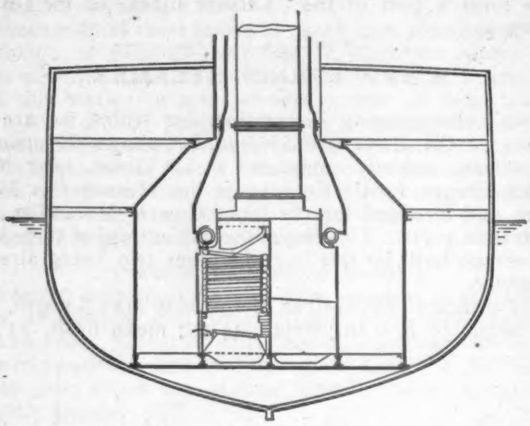


Fig. 2.

2,500 sq. ft. of floor room. In addition to the economy in space there are the further advantages of compactness and better distribution of weights, with opportunities for better ventilation and more convenient coal stowage, as the small room occupied by the steam generators permits the placing of the coal-bunkers immediately alongside of the fire-room. In addition to this we might mention the possible advantage referred to above, of a higher initial pressure and quadruple expansion, the economy of which will probably not be disputed by marine engineers.

A COFFER-DAM WITHOUT TIMBER OR IRON.

(Condensed from paper read by Robert L. Harris before the American Society of Civil Engineers.)

In 1869 two bridge piers were built in Croton Lake, N. Y., but owing to the failure of the railroad company it was not until 1879 that a single-track deck bridge of three 150-ft. spans was placed upon them. This bridge was supported by iron towers 41 ft. 7 in. in height, the four columns of each tower resting on 12-in. granite blocks 6 × 5½ ft. in size placed at the corners of the old masonry piers. These piers were 20 × 7 ft., 32 ft. high, and rested on timber cribs 47 × 35 ft. As shown by the drawings, these cribs were of 4-in. plank laid cob-fashion, gained 1 in. and bolted together; each was divided into nine compartments and filled in with stone. One crib was in 18 ft. and the other in 20 ft. of water, and both had rip-rap around them.

In the winter of 1888-89 the writer had charge of the reconstruction of the bridge to meet the requirements of increased traffic. After the contract was let, holes were drilled in the large stones of the masonry bases for tests and to admit grout filling for possible cavities. After the first few inches the drills penetrated with little or no obstruction, and the removal of the top stones showed that the interior of the bases was empty, or filled up with loose stone, dirt, rubbish, etc., enclosed by only a thin veneer of masonry. The only exception was at the corners, where solid masonry had been built up from the crib to carry the columns of the old bridge, under the orders of Mr. A. P. Boller, who built it.

The tops of the cribs were 5 ft. below the surface of the water, and so were just inaccessible, except by diving or use of caissons or coffer-dams. The materials of the inside of the old masonry beds were removed as well as possible by men in rubber clothing, hooks, grapplers, etc.; but the water was very cold and muddy, and did not permit accurate work. The bottom of the lake was irregular, with many bowlders, and before disturbing the piers they were reinforced by rip-rap on all sides, with a berme of 7 to 10 ft. at the top of the cribs and an outside slope of 1¼ to 1.

Several expedients were considered and rejected for excluding the water from the old masonry; forcing sheet piling through the rip-rap, covering the entire surface of the rip-rap with tarpaulin, etc. A tight bottom was desired at any level below the top of the crib, and tight sides thence to the water surface. The idea was to use the materials that were in place, and make a caisson therewith without disturbance, by cementing a portion of the loose mass of irregular stone-filling in the crib and as high as necessary to make good connection with the shell.

The track upon the bridge was over 75 ft. above the crib, and grout could be mixed upon the track over the crib and delivered directly through a hopper, pipe and nozzle. This was done, but the plan was soon changed to pumping in the grout immediately at the base. Holes were pushed among the stones until a few feet below the top of the crib. A long nozzle of 1¼-in. iron pipe connected to the discharge pipe of a No. 2 Douglas hand force-pump was inserted in one of these holes to its bottom, the water was rapidly pumped through for a few minutes, then the suction hose was suddenly transferred to a reservoir of grout composed of Alsen Portland cement and fine sharp sand, in equal parts, mixed immediately before use; two or three barrels only of the grout were slowly forced through and the nozzle was then withdrawn, but the hole maintained, and the same operation was proceeded with at other distant holes, seldom returning to any hole on the same day. Mr. Harris's belief was that in quiet water the cement would accrete on the surface of irregular stones at and below the level of injection, and that by consecutive slight accretions at proper intervals of time the voids between them would be filled.

After many days of this work a 6-in. Edwards centrifugal pump was able to lower the water in the pier and a few days later to pump it dry. The excavation to the crib was then carried on with so little water that at times a single man at the hand-pump kept it free, and finally it was possible to put in concrete, 1 part Alsen cement, 1 part coarse, sharp sand, and 4 parts broken rock in solidly rammed layers, up to the top of the old masonry shell.

Upon this filling new stone piers were built 22 ft. 10 in. × 15 ft. 4 in. at the bottom and 18 ft. × 6 ft. 9 in. at the coping, and a little more than 40 ft. high. The new superstructure on these piers consisted of three single-track deck-spans each 156 ft. 9 in. centers. The weight upon the bed-plates of the old iron towers had been over 17 tons per square foot. The weight of the new structure and its extreme load, applied within the area of the skeleton towers at top of the bases, was under 3 tons per square foot, delivered at the crib at less than 2¼ tons per square foot. During the construction of the new piers slow trains were running regularly over the old spans, which were supported by the tower columns resting on the four almost isolated corners of masonry.

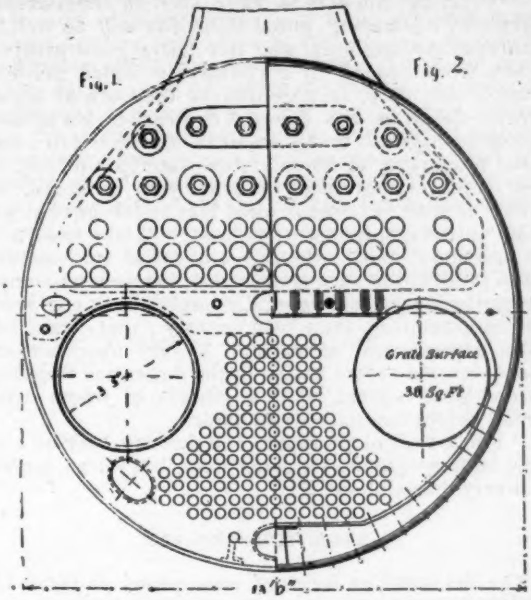
In this work Mr. Harris had made a cemented caisson in the crib, at a short distance below the top of coffer-dam, under water, using the loose stones there in place. Close observation during the operations failed to show loss of cement into the lake through the outside of the rip-rap. This is accounted for by the care exercised in forcing slowly but a little grout at a time at any one hole, and in giving it time to accrete upon the near rocks before another charge was applied.

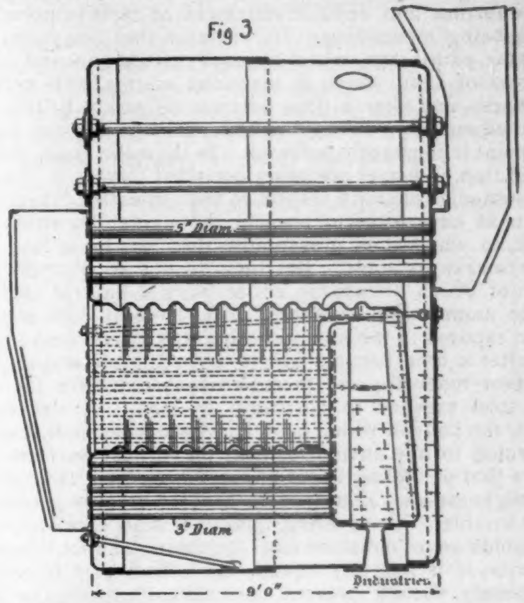
This work was emphatically not done of choice, but under the necessity of using the old foundations, and to secure the best results under the existing conditions.

In conclusion, Mr. Harris stated that this process of grouting can be successfully applied to rip-rap, rubble, gravel, sand and quicksand, and for the convenient construction of coffer-dams, breakwaters, etc., from the materials at hand or in place, and that it is useful for enlarging or repairing various subterranean or subaqueous structures and foundations.

In the discussion following several instances were

given of piers founded on loose stone and of masonry strengthened by forcing in cement. Mr. Harris said that about 100 barrels of cement were used for one of the piers and 134 for the other, and that considerable difficulty was experienced by the force-pumps clogging with grout when it was made as at first, with sharp, coarse sand. The difficulty was, however, relieved by using sharp, fine sand. Mr. Harris described taking from the foundations, 6 feet from the nearest nozzle, a broken stone with sharp, acute edges, on the vertex of which was an accretion of cement one-half inch thick. He particularly emphasized





THE CARSON BOILER.

the special point of the paper as being the idea of utilizing, in special cases, the existing loose materials for a tight permanent barrier, or for enlarged footing area, and that a very slow, gradual, intermittent application of liquid cement mortar in calm water would, by the sticking and setting of successive thin films form large accretions on the surfaces of the adjacent materials, which would thus become monolithic. The examples referred to in the discussion were of grouting in practically dry places, which is a familiar operation and well illustrated in the New Croton Aqueduct. Grouting under water has been done in England by W. R. Kinipple, who used experimental boxes filled with broken stone, to be joined by cements. In his harbor work, where the existing cavity was not limited, he constructed walls to confine the cement. Mr. Harris's method is a new application of cement under water, operating by gradual accretions, similar to natural processes, and not requiring any sides or bottom to confine it.

THE CARSON MARINE BOILER.

THE accompanying illustrations show an improved form of marine boiler devised by R. Carson, of Hull, England. Fig. 1 is a half front view; fig. 2 a half cross-section; fig. 3 a longitudinal section of a boiler built for the steamer *European*, a vessel lately refitted with high-pressure boilers and quadruple expansion engines by the Earle Shipbuilding Company at Hull.

The principal feature of this boiler is the use of two distinct set of tubes, the lower ones being 3 in. in diameter, and the upper ones 5 in. in diameter. The gases first pass from the combustion chamber to the lower tubes, and then through the upper ones on their way to the funnel. It is therefore likely that by this arrangement the temperature of the escaping gases will be considerably lower than in the ordinary marine multitubular boiler, and thus economy of fuel will be effected. Careful experimental trials and actual practice in ordinary working confirm this conclusion. The boiler, which is 13 ft. in diameter and 9 ft. long, has two corrugated furnaces 3 ft. 5 in. in diameter, with a grate surface of 38 sq. ft. and a total heating surface of 1,500 sq. ft. This boiler burns 20.3 lbs. of coal per square foot of fire grate, and is said to evaporate 10.1 lbs. of water per lb. of coal, calculated at an absolute pressure of 195 lbs. These results, if correct, are very satisfactory. Apart from economy of fuel, this design of boiler has an advantage in equalizing the temperature of the boiler when steam is being raised. The circulation of the water is ensured by the gases at their maximum heat passing through the lower set of tubes, and it will be seen that these tubes are so arranged that there is scarcely any water in the lower part of the boiler which does not have heat directly transmitted to it.—*Industries.*

NOTES FROM CHINA.

THE Viceroy of Kwangtung and Kwangsi has determined to build a railroad from Kowloon, opposite Hong-Kong, to Canton, a distance of 125 miles.

This will make the third railroad within the Chinese Empire, the first being the Tientsin-Kaiping Railroad, and the second, the North Formosa Railroad.

The Tientsin-Kaiping line has recently been extended to Linsi, a distance of 11 miles.

The building of the Kirin extension is expected to go on during the present year, but as yet no definite announcement has been made.

MINING.

The Viceroy of Hupei, Chang-Chih-Tung, has just issued a proclamation urging native companies to open the coal and iron mines of Hupei, and promising them government assistance and support in introducing foreign machinery, and obtaining the services of foreign engineers.

Six American miners and an Ingersoll air-drill plant have been recently added to the force and machinery of the Jeho silver-mines (Northern Chihli) by the manager, Tang-King-sing, who is also the successful manager of the Kaiping colliery. The Jeho mine has not fulfilled the expectations entertained in regard to it up to this time, but work is now to be pushed more energetically in the hope that it may soon be put on a paying basis.

John A. Church, formerly the Superintendent of the Jeho mine, has returned to the United States. Before his departure he visited Kurichow at the request of the Chinese authorities, and his visit led to important discoveries of coal-mines in that province.

NATURAL ASPHALT AND THE PRESERVATION OF IRON AND STEEL STRUCTURES.

By A. B.

In the valuable paper of Mr. Woodruff Jones on "The Preservation of Iron and Steel Structural Work," in the April number of the JOURNAL, an observation is made respecting "asphalt and coal-tar paints," which requires some further and definite statement of facts to prevent it from being misleading. He remarks that "asphalt and coal-tar paints run when exposed to the sun and other sources of heat, which is a serious matter with vertical surfaces, and after a time become extremely brittle and scale off entirely, leaving the under surface exposed unless the paint is constantly renewed. In the mean time, the exposed iron and steel are being corroded by rust." This is undoubtedly true with respect to such so-called "asphalt" paints as have hitherto been in the market for structural work, to which it is presumable that Mr. Jones intended his remarks to apply. But they do not at all apply to a paint of which almost the entire body is natural asphalt, as the name ought to imply. Such a paint does not run when exposed to the sun and other sources of heat; does not after a time become brittle and scale off and require constant renewal; and therefore does not leave the iron and steel exposed to corrosion by rust. A well-made paint, the body of which is of true natural asphalt, can be subjected to any amount of heat on vertical surfaces not above that of boiling water and not run; and its qualities of toughness and adhesiveness are remarkably persistent and durable. Its covering quality is also excellent, and for exclusion of moisture and prevention of rust it has no superior, if it has any equal. So adhesive is it and so completely does it prevent corrosion, that when a new coating is required it is best to apply it over the old paint, with little or no scraping, thus saving a considerable item in the cost of maintenance.

The trade use of the term "asphalt," as applied to certain coal-tar products, has naturally led to some confusion of mind on the subject. But, while these artificial products have a certain resemblance to natural asphalt in some of their physical properties, they are yet chemically very unlike. They are, in fact, so wide apart in essential qualities that they are as inappropriately coupled together in the same sentence as if closely related, as things volatile and involatile, or destructible and indestructible. There is no product of coal-tar, until the final residuum of coke in the still, the constituent oils of which do not gradually volatilize by the heat of the sun; and coal-tar products suitable for use in paints also easily become fluid when subjected to heat, so that they are liable to run on vertical surfaces, until, by evaporation, they are so far advanced on the road to brittleness that they solidify, and by a little further progress in the same direction they become brittle and scale off. On the other hand, a true asphalt paint applied on vertical surfaces does not become fluid when exposed to the sun or other source of heat; and its constituent oils are absolutely non-volatile at the highest temperature of the sun's heat, and do not change by oxidation under any ordinary atmospheric conditions—very essential qualities of permanence. It is these properties which make the finer kinds of asphalt so important in the manufacture of coach and other black or dark Japan varnishes. The wonderful permanency and durability of natural asphalt has been demonstrated by the experience of ages. For example, Herodotus tells of its use in the construction of the walls of Babylon, and this is confirmed by modern travelers, who find abundance of asphalt among the ruins of this ancient city. Sir R. Kerr Porter speaks of picking up among the ruins of Babylon "large cakes of asphalt, more than 10 in. long and 3 in. in thickness, appearing to have been the casing of some work, perhaps the lining of a water-course." These had lain exposed to the elements for more than two thousand years, and yet retained their forms so as to indicate their probable purpose. With any substance that becomes brittle and perishable under the heat of the sun this would, of course, be impossible.

SOUTH AMERICAN NOTES.

BRAZIL.

Our Brazilian correspondent, writing about the middle of March, says that he understands that announcement has been made that capable engineers would at present do well to try Brazil. Upon this head he makes the following remarks, which, we believe, will be useful to engineers in this country and elsewhere.

"So far as I am able to judge, such an announcement is decidedly misleading, and I think you will do well to discourage any engineer who has fairly good prospects at home from coming to a country in which politics and finance are both as unsettled as they are at present in Brazil, unless he has either a contract in his pocket provided for payment to his credit in an American bank of a good proportion of its salary in American money, or unless he has extraordinary influence with influential Brazilians. It must be borne in mind that under the new Government patronage, for a time at least, will take small account of individual merit; that the amount of work actually in hand in Brazil is very small; that the foreign companies executing works here generally import their engineers under contract from their own country; that Brazil has but little capital, and at present a very uncertain credit. Moreover, the recent smash in the Argentine Republic has turned loose a great many engineers, of whom many try Brazil before crossing the Equator.

"For a skillful promoter Rio Janeiro may be a profitable hunting-ground for some time, but for an engineer it is a very doubtful one."

ARGENTINE REPUBLIC.

The Transandine Railroad was opened as far as Uspallata, and trains commenced to run through March 1. The terminus of this line is now close to the end of the mountain section, but when it will be completed is very uncertain, as work is for the present suspended on the crossing of the Andes, owing to financial disturbances.

Argentine managers are urging a general reduction of railroad fares and freight rates. In the present condition of the country they believe that this will be beneficial, both in reviving business and in improving the condition of railroads. The difficulty, however, is that most of the lines are owned in England, and that it is almost impossible to make the London directors appreciate the true state of affairs, or to understand that an increase in profitable business may often be brought about by reduction in rates in a new country.

The first iron made in the Argentine Republic was made from hematite ores taken from the Romay Mine, recently discovered in the province of Catamarca. The ore is said to be of excellent quality, and to exist in that province in considerable quantities. The iron made from it in a small furnace built for experimental purposes was of a very good quality. It is not at all likely, however, that a country in which fuel is as scarce as it is in the Argentine can ever become a great iron-making country. Fuel as well as iron ore is urgently needed.

THE UNITED STATES NAVY.

The third trial of the *Bennington* began April 1, but was postponed for a day on account of the breaking of a pump-rod. The damage was repaired and the trial made finally on April 2, when the ship made the required five hours' run, extending from a point off Matinecock Light through Long Island Sound to near Bartlett's Reef Light. The data reported are: Average steam pressure during the run, 161.6 lbs.; vacuum, 24.4 in.; revolutions of main engine, 151 per minute. The engines worked smoothly and well, developing a little more than the 3,400 H.P. required.

It is stated that no contract will be awarded for the new torpedo boat, for which bids were received some time

ago; and it is not unlikely that the boat will be built at the New York or the Norfolk Navy Yard.

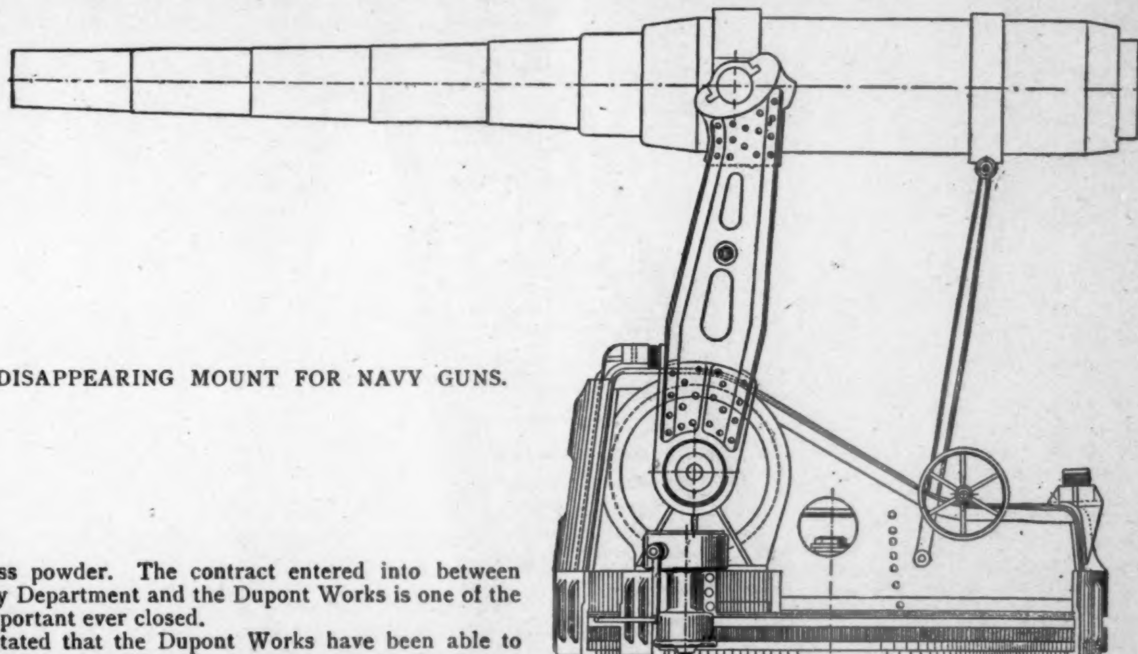
ORDNANCE NOTES.

The Secretary of the Navy has closed a contract with Dupont & Company, of Wilmington, Del., by which that firm will be enabled to establish a plant at their powder mills for making gun-cotton and smokeless powder for naval uses. The plant to be located at the Dupont Works is the first of its kind in this country. Experiments have been conducted during the last year by the naval ordnance experts with high explosives, and some valuable results have been attained, notably with emmensite, a material in force about equal to that of gun-cotton. The latest report from the Torpedo Station, where the chemical experiments have been conducted, show that the powders adopted abroad fail in complete homogeneity and perfect stability. Meanwhile the foreign tests are closely observed and samples are analyzed at home, with the result that the bureau is ready to domesticate in this country the manufacture of smokeless powder. The contract entered into between the Navy Department and the Dupont Works is one of the most important ever closed.

It is stated that the Dupont Works have been able to make lately a considerable improvement in the brown prismatic powder used for high-power guns. In a recent test at the Naval Ordnance Proving Ground, in an 8-in. breech-loading rifle of 35 calibers length, it gave to the projectile an initial velocity of 2,130 ft. per second, with a pressure in the powder chamber of only 14.8 tons per square inch. This is equivalent to an increase in the power of the gun, which is designed to give an initial velocity of 2,080 ft., with a chamber pressure of 15 tons. The improvements in the powder have been such as to give it greater uniformity of combustion, so that the speed of the projectile is more gradually accelerated throughout the length of the gun, until it leaves the muzzle with a higher velocity than could be attained with the older powder.

The Bureau of Ordnance has prepared drawings for a hydraulic disappearing mount for a 10-in. breech-loading rifle. It resembles the pneumatic carriage in general principle, except that water under a pressure of 800 lbs. to the square inch is used in place of compressed air. The gun rests upon two arms, the lower ends of which are keyed to the two ends of the axis of a horizontal cylinder. This cylinder is divided into two compartments by a fixed diaphragm. The water is admitted through valves into these compartments and the gun is elevated. By turning the axis of the cylinder the water is forced out through small grooves, resisting the recoil sufficiently to bring the gun to an easy stop at the loading position. A mount is to be constructed on these plans and thoroughly tested.

For the accompanying illustration of this disappearing gun-mount we are indebted to the *Army and Navy Register*, of Washington.



THE DISAPPEARING MOUNT FOR NAVY GUNS.

THE SUBMARINE MINE AND TORPEDO IN HARBOR DEFENSE.

By First Lieutenant Joseph M. Califf, Third U. S. Artillery.

(*Continued from page 170.*)

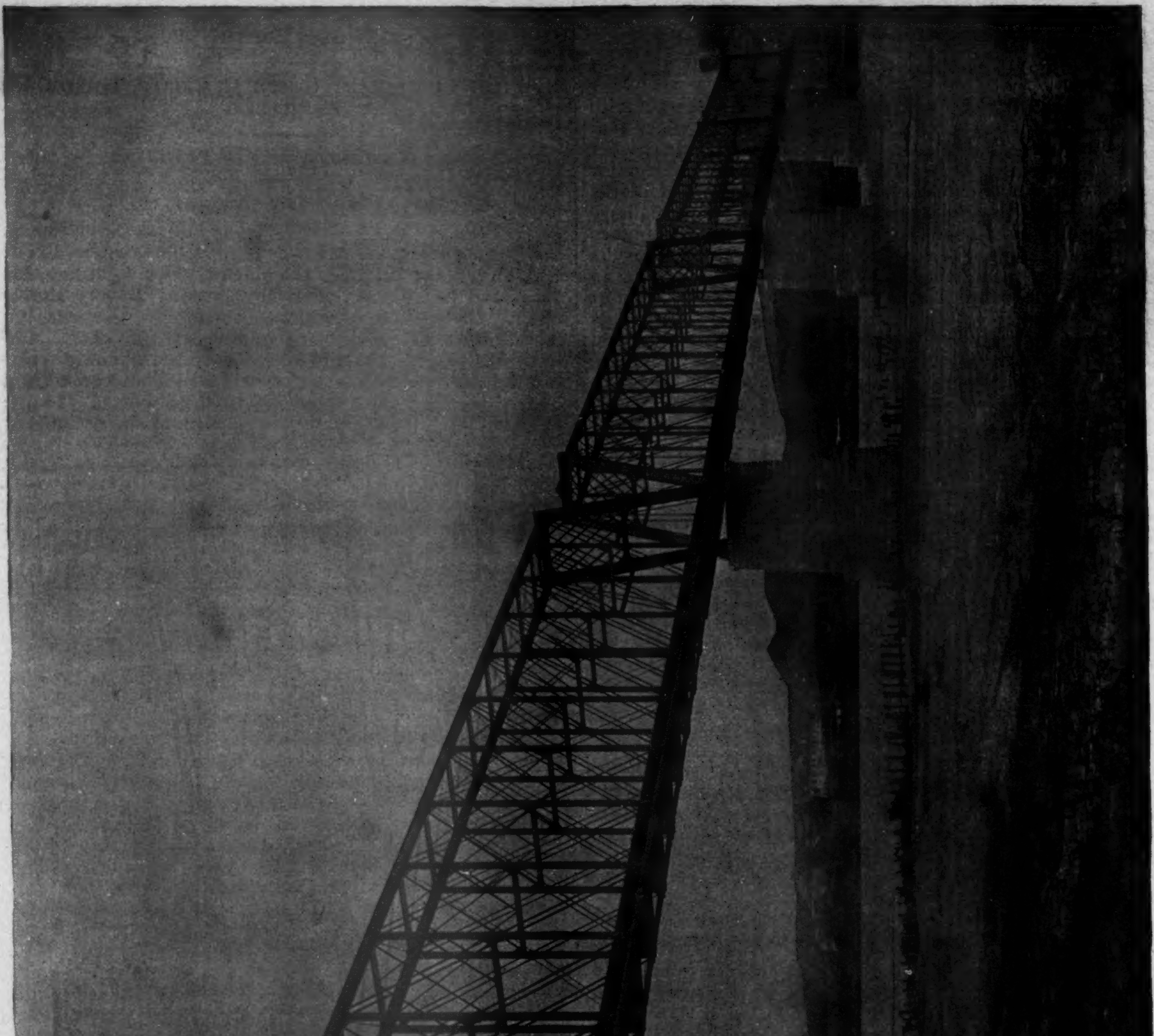
XII.—TORPEDOES.

A sea-coast attack in the olden time—a fight between ships and forts—was, relatively speaking, a very simple affair. Given depth of water and manœuvring space, the factors were simply those of relative strength of wall and bulwark, weight of metal and good or bad gunnery. For the defense, the only auxiliary aid available came from booms, to delay the approach, and fire-ships, to damage an assailant. How greatly the conditions have changed, so far as concerns the defense, may be gathered from a statement of what is now considered necessary for the proper protection of a harbor. In addition to forts and batteries, the first need is a carefully planned system of controllable submarine mines; then controllable torpedoes ready to dart out from the shore at the will of their operator; floating batteries of light draft, armed and armored more heavily than any probable adversary, and lastly, swift torpedo-boats for the protection of the mine-field, for harassing a blockading fleet, to pounce upon an enemy's ship that may become disabled or get aground, and to take every advantage afforded by fog or smoke or darkness for attacking him.

What has heretofore been said concerning the defense of a harbor has had reference to the purely passive or stationary means employed for that purpose. Under the head of *torpedoes* reference is had to all the movable and aggressive contrivances for inflicting injury upon an enemy's shipping, whether acting upon or beneath the surface of the water. Like submarine mines, torpedoes are divided into two general classes—*uncontrollable* and *controllable*—the name clearly indicating the characteristic feature of each.

XIII.—UNCONTROLLABLE TORPEDOES.

In the uncontrollable class are included every torpedo which passes, when once launched, wholly beyond the control of the operator, both as regards its direction and its propelling force. Various methods have been adopted,



THE SIOUX CITY BRIDGE OVER THE MISSOURI RIVER.

with more or less success, looking to the maintenance of a true direction when once the torpedo has started upon its course, but no means have been devised for securing its explosion except by contact with some other body, or by mechanism that shall act at the expiration of a definite period of time, regardless of its then position in relation to the object of attack. In this class are the *projectile*, the *rocket*, the *drifting*, and the *auto-mobile* torpedo.

Projectile torpedoes. All torpedoes projected against an enemy, whether the actuating impulse is extraneous to themselves or self-contained, can be classed under this head, but the term as usually applied is restricted to "a case of explosive projected through the water from a submarine gun." The best-known example of this class is that invented by Captain Ericsson, intended to be fired from a breech-loading gun or tube built into a vessel especially designed for the purpose (the *Destroyer*). The gun is submerged some 7 ft., closed by two water-tight valves, one of which, of wood, is supposed to be shot away and replaced after each discharge. A gunpowder charge of 25 lbs. gives a range of some 400 ft. to a torpedo carrying 300 lbs. of explosive. It was experimented with in 1881 with fairly satisfactory results. Recently it has been taken in hand again, and further trials will shortly be had. The claim made for this system of torpedo discharge is that the vessel can be so heavily armored as to be practically invulnerable—wholly unlike the ordinary torpedo-boat.

Neither the *rocket* torpedo, which class embraces all those that depend for their propulsion upon the gases developed by the burning of some form of rocket composition, nor the *drifting* torpedo, have at present any recognized place in the list of practicable weapons.

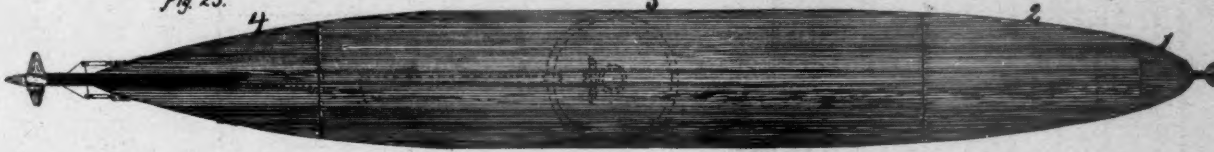


Fig. 23.

Auto-mobile torpedoes. The auto-mobile fish torpedo is the only one of the uncontrollable class that has reached a practical stage of development, and that has a recognized place in the torpedo armament of the great powers. In it the power of propulsion is self-contained, and it may be run either upon or at any desired depth below the surface of the water. The European Whitehead is the best-known example of this class, but this has now a more than promising rival in the American Howell. The German Schwartzkopf is simply a modified Whitehead. All the weapons of this class are alike in that they are cigar-shaped bodies, of a length varying from 9 to 19 ft., with a maximum diameter of from 14 to 18 in.

The *Whitehead* torpedo first appeared upon the trial ground in 1868, under the auspices of the Austrian Government. As at present constructed it is a cigar-shaped body of steel or phosphor-bronze divided into six compartments for the propelling, directing and exploding mechanism. It is driven by two screws, revolving in opposite directions upon one shaft, the motive power being air-compressed under a pressure of about 1,000 lbs. per square inch, and an engine. It has an extreme range of about 800 yards, and a speed up to the half of this distance of 30 knots per hour. The details of the latest models are given as follows: Length, 11.5 ft.; diameter, 17.5 in.; charge, 110 lbs. wet gun-cotton, and weight about 800 lbs. In the Whitehead advantage is taken of hydrostatic pressure to regulate the immersion. It is maintained at a constant depth by horizontal rudders, controlled by what are known as "immersion regulators;" and in a vertical plane by fixed vertical vanes. The chief defect of this torpedo seems to be a want of stability in a horizontal plane. It is at present the only one in actual service—using the name to indicate the type—and forms the armament of all European torpedo-boats. The Schwartzkopf is, in all essential particulars, a Whitehead, differing from it in the material for the air-chamber (phosphor-bronze), and in some slight degree in the steering apparatus and motive machinery. There is considerable variation in dimensions, weight and charge of explosive.

The *Howell* torpedo (fig. 23) has much the general appearance of the Whitehead. The shell is of brass, the other parts of steel or phosphor-bronze. The body is divided into four sections: (1) The nose, carrying the firing-pin and its mechanism; (2) the explosive charge and detonator; (3) the fly-wheel and screw gears, and (4) the diving and steering mechanism. The propelling power is stored in a steel fly-wheel, given a high velocity of rotation before the torpedo is launched. This power is transmitted directly from the fly-wheel to the propellers. The diving mechanism, which controls the submersion, is operated upon by hydrostatic pressure, and can be set for any depth from 1 to 12 yards. After launching it automatically takes the depth for which set, and maintains its course both vertically and longitudinally. The fly-wheel can be worked up to 10,000 revolutions per minute, which will give a speed of about 22 knots for 400 yards, and an extreme range of about 1,000 yards, although beyond the shorter distance there will be a considerable loss of speed. The 8-ft. torpedo will carry 70 and the 9 ft. 90 lbs. of explosive. For accuracy it is superior to the Whitehead, but the latter has the greater range and velocity.

Torpedo discharge. An initial impulse is necessary to throw the torpedo clear of the ship into the water. This impulse may be given either by steam, compressed air or gunpowder. Air and gunpowder are now usually employed, the latter becoming the prevailing method. The discharge may be either below or above the surface, either from fixed, or from training or turntable tubes. For under-water discharge the tubes are always fixed, and from 7 to 9 ft. below the surface; either in the stem for forward or on the sides for broadside discharge. Owing to the turmoil created by the propeller, stern discharge is apt to be uncertain. For above-water discharge the tubes are usually movable, and from 5 to 9 ft. above the water-line. To aid in accuracy of discharge, spoon tubes are often provided. These prolong the tubes about half the length of the torpedo beyond the sides of the vessel, and may be rigged out at pleasure.

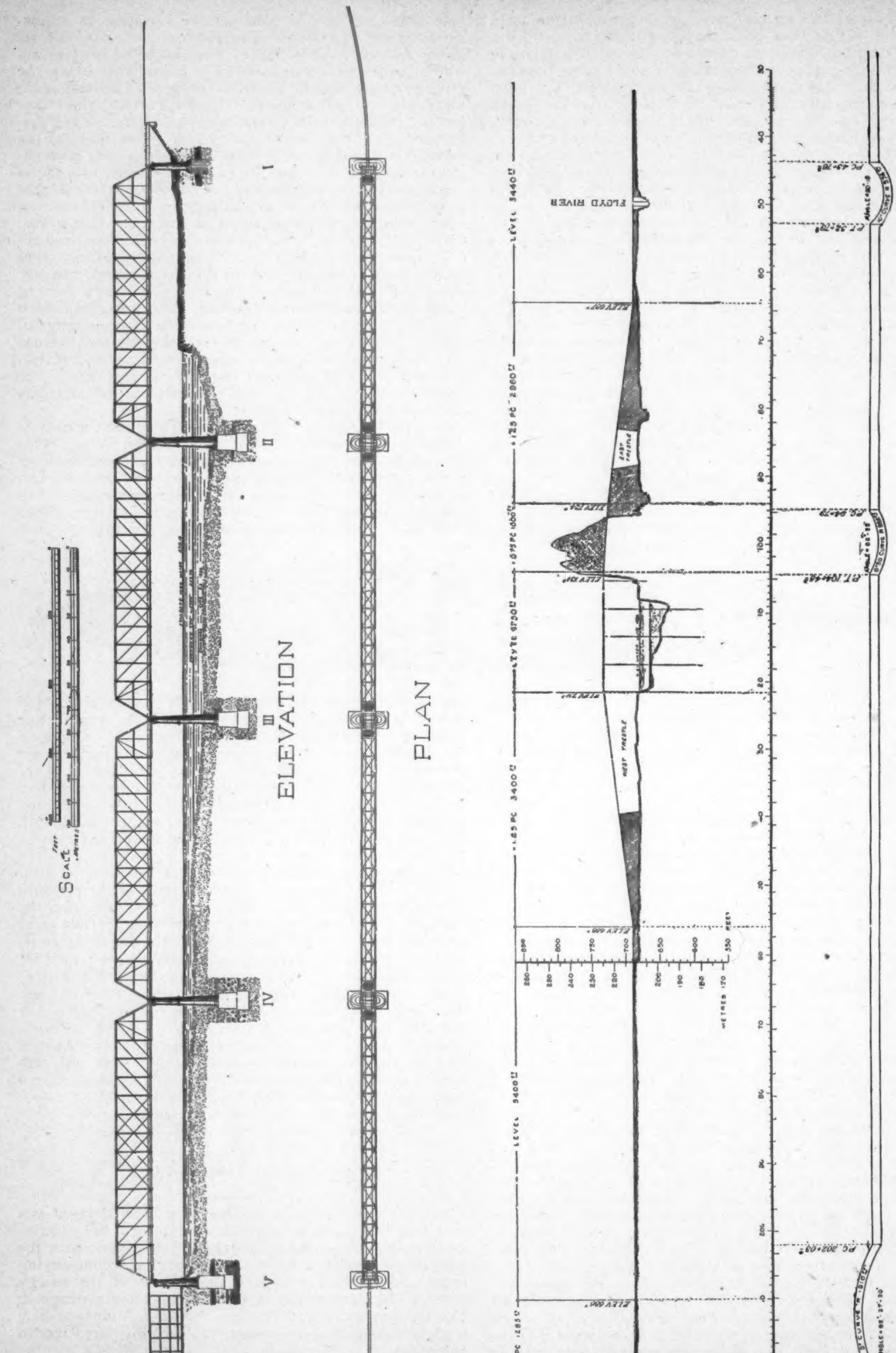
For gunpowder discharge the French use a disk of ¼ lb. of compressed gunpowder. With air impulse the pressure is something over one atmosphere. In either case the force employed is only sufficient to throw the torpedo clear of the side. It should fall flat upon the water, when its own motive and directive apparatus sets it upon its course at the proper depth, and supposedly in the right direction. Generally speaking, England and France employ gunpowder impulse only; Austria, Germany and Spain, air impulse, and Italy and Russia both. England, France and Italy use both above and under-water tubes; Austria and Russia above-water discharge only. Not only are torpedo-boats provided with tubes and torpedoes, but a large percentage of recently constructed war-ships have a torpedo in addition to their ordinary armament.

(TO BE CONTINUED.)

THE SIOUX CITY BRIDGE.

MR. MORISON'S report on the Sioux City Bridge* is a very fully illustrated monograph, containing a full description of the bridge and approaches, from which, with the permission of the author, we have taken the accompanying engravings and a condensed description of the bridge itself. The bridge was built to connect the Chicago & Northwestern and the Chicago, St. Paul, Minneapolis & Omaha Railroads by a crossing of the Missouri River in

* THE SIOUX CITY BRIDGE: *A report to Marvin Hewitt, President of the Sioux City Bridge Company.* By George S. Morison, Chief Engineer.



THE SIOUX CITY BRIDGE OVER THE MISSOURI RIVER.

the neighborhood of Sioux City, and was constructed under the charge of Mr. Morison as Chief Engineer.

It is a single-track railroad bridge, and as originally designed consisted of three spans of 400 ft. each, resting on masonry piers, with a plate girder span extending from the east pier to the bluff, and with a short deck span connecting the west pier with the west approach. Owing to changes in the channel of the river, which in the winter of 1887–88 changed to the west side instead of the east side of the river, it was decided to increase the length of the bridge and to make it consist of four spans of 400 ft. each and a plate girder span 61 ft. 6 in. long east of pier I, the total length of the bridge proper being 1,675 ft.

The east approach includes a bridge across the Floyd River, consisting of three spans of plate girders resting on two masonry abutments and two iron cylinder piers, all having pile foundations. It also includes a timber trestle 600 ft. long. The remainder of the line is of earthwork, all being embankment except a large cut through the bluff immediately east of the bridge. The total amount of material in this approach was 166,929 cub. yds.

The west approach comprises a timber trestle 1,840 ft. long, extending west from pier V, beyond which it is all built as an earth embankment, the total amount of the earthwork in this approach being 66,382 cub. yds. Both approaches are built with a maximum grade of 1.25 per cent., or 66 ft. to the mile.

The illustrations herewith show an elevation of the bridge and approaches; a plan of the same and the general alignment of the bridge and approaches. The large plate is a general view of the bridge, taken from a photograph.

The superstructure of the bridge proper, as above noted, consists of four through spans and one plate girder, each through span being 400 ft. long between the centers of the end-pins, divided into 15 panels of 26 ft. 8 in. each, the trusses being 50 ft. deep and placed 22 ft. between centers. Expansion is provided on piers I, III and V.

Excepting the web plates of the plate girder, the entire superstructure is of steel. The east span is of imported steel from Scotland; the other three spans are of American steel. The imported steel, it is stated, was a little more uniform in quality than the American, but was less uniform in finish and sections, and the weight of this Scotch steel span is slightly in excess of that of the others, being 1,114,295 lbs., while the three spans of American steel weigh 3,330,172 lbs. The plate girder weighs 41,340 lbs., making the entire weight of iron and steel in the superstructure 4,485,807 lbs.

The trusses are proportioned to carry a moving load of 3,000 lbs. per lineal foot, but in calculating the effects of a moving load the portion of any strain in excess of that which would have been produced by a uniform load of equal amount was taken on a basis of 5,000 lbs. per foot. The top lateral system is proportioned to resist a wind pressure of 300 lbs. per lineal foot, and the bottom lateral system 500 lbs. per lineal foot. The floor system was designed for a uniform load of 6,000 lbs. per lineal foot.

The compressive strain in the top chord is limited to 14,000 lbs. per square inch of balanced section. The tensile strain in the bottom chord is limited to 13,000 lbs. per square inch, and that in the web members is kept somewhat lower.

The spans were erected in a remarkably short time, as is shown by the following statement. The east approach girder was placed November 22, 1888. In the through span I–II, the first iron was placed August 4, 1888, and the span swung August 9; in through span II–III the first iron was placed September 11, 1888, and the span swung September 17; in through span III–IV the first iron was placed October 20, 1888, and the span swung October 26; through span IV–V the first iron was placed November 13, 1888, and the span swung November 18.

The timber floor was put on by the Company's men working under the direction of the Resident Engineer, and the painting was done in the same way.

In one respect this bridge differs from other bridges over the Missouri. The piers are not founded on rock or is there any available rock to be found in the location. The bluffs east of the river rest on a prealluvial gravel which extends under the river, and the piers are founded in this gravel to a depth of 50 ft. below the alluvial deposit—that is, the piers are not founded in the deposit made by the river, but in an entirely different material which is permanent in character, and is the same material which forms the foundation of the bluffs adjoining the river. This condition of things required peculiar arrangements for the substructure of the bridge.

This substructure comprises a small abutment at the east end and five piers, which are numbered from east to west. Pier I has a pile foundation, and the other four are founded on pneumatic caissons of the following dimensions: Pier II, 28 × 60 × 18 ft.; pier III, 28 × 60 × 18 ft.; pier IV, 28 × 60 × 18 ft.; pier V, 23 × 50 × 15 ft. The caissons are built of pine timber with oak sills and iron cutting edges planked with two thicknesses of 3 in. pine plank. The caissons are all surmounted by timber cribs, those of piers II, III and IV having the corners cut off so as to make them of octagonal section, and that on pier V being of rectangular section. The cribs are built of pine timber planked with one thickness of pine, the corners being plated with ½-in. iron. Both caissons and cribs were filled with Portland cement concrete.

The caissons were built in position on pile false-work and lowered on long screws to the bottom of the river. The pneumatic machinery was as set up on the east side of the river immediately north of the bridge line. In the spring of 1888 it was transferred to the west side of the river and set up there. A temporary pile bridge was built 50 ft. north of the bridge line, extending entirely across the river. A service track was laid across this bridge, and it was used for the handling of material and to carry the pipes leading air and water to the caissons. A year later a similar pile bridge was built from the west shore as far as pier IV.

Pier I is founded on piles which were driven in the excavation made on the shore at a considerable distance from the river. The piles were cut off at an even elevation and capped with two courses of 12 × 18-in. oak timber. The masonry was erected on top of this timber. This pier is 57 ft. in height, and at the top is 35 × 8 ft.

At pier No. II the caisson was sunk into place through the superficial deposit of sand, clay, gravel, and boulders to its final position on the bed gravel. The sinking occupied nearly six months, including delays caused by high water. The pier which stands on this caisson is 97 ft. 6 in. in total height of masonry.

At pier III the caisson was sunk through fine sand; then through a mass of mud, snags, gravel and boulders; then through a layer of coarse gravel, beneath which was clean coarse sand, the lower part of this layer being mixed with a constantly increasing amount of gravel. The work of sinking this caisson was delayed by the spring floods. The pier here is 95 ft. in height from the top of the timber crib.

At pier IV there was less delay in sinking the caisson, as most of the work was done in the summer time, and there was less delay by flood. The material through which the caisson was sunk was first fine sand, then coarse sand, gravel and mud, then a smaller sand with occasional boulders, then through a mixture of sand and clay, then through coarse sand and gravel, and finally through fine compact sand. The total height of the masonry of this pier from the top of the crib was 96 ft. 6 in.

The foundation of pier V, which was put in before that of pier IV, was a little delayed by high water, and presented some difficulties, owing to the greater depth of water in the channel and the material through which it had to pass, which was first a soft blue mud followed by the same mud containing more or less sand, below which was a layer of 3 ft. of clean sand; below this again was coarse gravel interspersed with layers of clay, then coarse sand again followed by more blue clay, which continued to the bottom of the foundation. Much material was found here which could not be pumped, and clay-hoists had to be used. The height of this pier from the top of the crib was 50 ft. 2 in.

The dimension work of the five piers which are exposed to frost is of granite, quarried at Morton, Minn., and the remainder of the work is of limestone from Mankato,

Minn. The abutment at the east end of the bridge is a small piece of limestone masonry.

The amount of masonry and concrete in the bridge is as follows:

	Masonry.	Concrete.
Pier I	778.79 cub. yds.	....
Pier II	1,791.48 " "	1,915.44 cub. yds.
Pier III	1,749.27 " "	1,879.35 " "
Pier IV	1,781.06 " "	1,879.35 " "
Pier V	817.92 " "	1,489.03 " "
East abutment	71.69 " "	18.37 " "
Total	6,990.21 " "	7,181.54 " "
Total masonry and concrete		14,171.75 " "

The bridge and its approaches are owned by the Sioux City Bridge Company, which is controlled by the Chicago & Northwestern Company. The east approach is 1.65 miles long from its connection with the main line of the Chicago, St. Paul, Minneapolis & Omaha track to the east end of the bridge. The west approach is 1.92 miles long from pier V to its connection with the Chicago, St. Paul, Minneapolis & Omaha track in the bottom land west of the river. The Sioux City Bridge Company also owns a second connecting track 0.18 miles long, used in reaching the Sioux City passenger station, so that the total mileage owned by the Company is 4.04 miles.

A considerable amount of riprapping was done around the several piers. The only rectification done consisted in building a small piece of dyke above the bridge on the west side, which was put in to control the river in case the channel should again be thrown by some temporary disturbances toward the west side of the river.

The work was undertaken by Mr. George S. Morison as Chief Engineer. On May 1, 1887, a professional partnership for two years was formed between Mr. Morison and Mr. E. L. Corthell. After the termination of this partnership on April 30, 1889, Mr. Morison remained Chief Engineer in charge. Mr. E. Gerber was Resident Engineer, assisted by Messrs. A. B. Corthell, J. W. Freger, C. H. Mayne, and Andrew Thompson.

The contractors for the masonry were T. Saulpaugh & Company; for the superstructure, The Union Bridge Company; for the erection, Baird Brothers, Mr. George Buchan being Superintendent of erection; for the earthwork, McNamara & McCarthy, and for the trestle work, Wakefield & Hill.

The sub-contracts were let in August, 1887; the erection of the last span was completed November 20, 1888; the first train crossed the bridge on November 20, 1888, and on December 5 the bridge was formally tested. Its entire charge was turned over to the Operating Department of the Chicago, St. Paul, Minneapolis & Omaha on August 8, 1889, and it has since been in regular use.

ARMY ORDNANCE NOTES.

THE War Department has already prepared for issue proposals for materials to be used for the manufacture of guns under provisions of the Fortifications act, to take effect with the new fiscal year, as follows:

For 25 sets of forgings for steel field guns of 8.2-in. caliber; for 16 sets of forgings for steel field mortars of 3.6-in. caliber, and for 16 steel carriages for the same; for steel forgings for 8, 10 and 12-in. rifled coast-defense guns; for 8, 10 and 12-in. armor-piercing projectiles; for excavations and iron work at the new south wing of the Watervliet Gun Factory. For the large coast-defense guns above referred to Congress appropriated $800,000 for the procurement of the necessary forgings, and the material will be assembled at the Watervliet factory and the finished guns turned out. The 3.6-in. mortars mark a new departure in military field operations. They are intended to replace the small cohorns which are used in trenches for shelling an enemy behind earthworks or like defenses and out of the direct fire of field guns. Their range is nearly three times as great as the cohorn smooth-bore mortars, the projectile is more than twice as heavy, and great accuracy of fire is obtainable. The weight of the piece is about 525 lbs., so that it can be easily transported in a wagon or moved about by men in the trenches. The armor-piercing projectiles are to be manufactured by a domestic concern, but upon specifications that will secure the use of some one of the modern European patented processes. For their manufacture an appropriation of $100,000 will be available. The work of construction at Watervliet, for which advertisements have so far been prepared, will, it is estimated, cost about $75,000.

Bids were recently opened in the Ordnance Office of the War Department for the construction of 25 carriages for 12-in. breech-loading rifled mortars. Only two bids were received. The Morgan Machine Works, of Alliance, O., offered to build eight carriages, complete, for $65,405, delivering the first one within 18 weeks and the other seven at the rate of one every six weeks after, or 25 carriages for $7,725 each, the delivery of the first eight to be as above, and the remaining 17 at the rate of one every three weeks. The Builders' Iron Foundry of Providence, R. I., offered to build eight carriages for $14,000 each, or ten for $130,000, and each additional carriage for $12,500, delivery of the first carriage to be in one year, the second four months later, and the third three months later, and the remainder at intervals of two months each. The bid of the Morgan Iron Works is by far the lowest and the delivery much the more prompt, but the Builders' Company claim to control the American right to a foreign patent, which they assert will prevent any one else from building in this country such carriages as the Government wants.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.
XVI.—PAINT SPECIFICATIONS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page 177.*)

WE had intended to give in this article a further discussion of "How to Design a Paint," comprehending in the discussion the liquid used and the proportions of pigment and liquid, but we find a little further experimentation necessary in order to decide one or two points involved, and are compelled to postpone the conclusion of the subject "How to Design a Paint," until a subsequent article.

In this article we will give two of the specifications which have thus far been issued for different paints by the Pennsylvania Railroad Company, with the reasons why for each of the specifications.

The first paint specifications were for the material used for cabin car color. These specifications have been re-

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the Method of Purchasing Oils; No. IX, also in the July number, on Hot Box and Lubricating Greases; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

vised twice, the form given below being the latest issue, as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Cabin Car Color.

The standard cabin car color is the pigment known as scarlet lead chromate. It is always purchased dry.

The material desired under this specification is the basic chromate of lead ($PbCrO, PbO$), rendered brilliant by treatment with sulphuric acid, and as free as possible from all other substances. The theoretical composition of basic lead chromate is nearly 59.20 per cent. of normal lead chromate, and 40.80 per cent. of lead oxide, but in the commercial article it is found that a portion of the sulphuric acid added to brighten the color remains in combination apparently with the normal lead chromate, slightly increasing the percentage of this constituent. The sulphuric acid thus combined should not exceed one-half of one per cent.

Samples showing standard shade will be furnished on application, and shipments must not be less brilliant than sample. The comparison of sample from shipment, with the standard shade, may be made either dry or by mixing both samples with oil.

Shipments of cabin car color will not be accepted which:

1. Contain barytes or any other adulterant.
2. Show on analysis less than 57 per cent. or more than 60 per cent. of normal lead chromate, including the sulphuric acid combined as above stated.
3. Show on analysis less than 38 per cent. or more than 42 per cent. of lead oxide, in addition to lead oxide in the normal lead chromate.
4. Vary from standard shade.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., February 18, 1891.

Considerable discussion arose when these specifications were first prepared, as to what sort of pigment should be used for cabin car color. It is well known that the cabin car forms the rear end of every freight train, and is the car in which the crew stay and protect themselves from the weather, etc., when they are not at work somewhere along the train. So far as the color of the car is concerned, this principle is involved, namely, that the rear end of every freight train is subject to danger from any succeeding train, and it therefore becomes of the utmost importance that the rear end should be properly protected. It is, of course, well known that when a freight train or any other train stops on the track, the rear brakeman goes back a proper distance to prevent any succeeding train from running into the one which is standing. It is also well known by those who are at all familiar with railroad operation, that the rear end of every train is protected in the night-time by signal lamps, and in the daytime by flags. In order, however, to make the protection as complete as possible, it was decided, and is the principle which is used everywhere, to make the cabin car itself a danger signal. It is well known that red is the color used on all railroads for the danger signal, and consequently the cabin cars are painted red. In order to make this red as prominent and pronounced as possible, and to have it attract as much attention as possible, it must be a bright one. A dull red or a brown would not be so marked or prominent. In looking over the pigments which could be used for this purpose, a number of considerations had to be taken into account. The iron oxides were too dull. Red lead was too much of an orange. Either of these brightened up with any of the aniline colors or the lakes were too fugitive, and practically the choice was narrowed down ultimately between genuine vermilion and scarlet lead chromate. The difference in price largely decided the choice of scarlet lead chromate as cabin car color.

Since this material was adopted as standard, a number of new pigments have come forward which are extremely brilliant in color, and which are made apparently by precipitating some of the coal tar colors with lead salts. We have examined some six or eight of these which appear in the market under various fanciful names, and have also made exposures of a number of them. We have not succeeded yet in finding any which had even a moderate permanence under exposure. They all fade rapidly, and with now some five or six years' experience, we know of nothing better for a good, fairly permanent bright red, than scarlet lead chromate.

It will be noted that the material is bought dry. The reason for this is that this pigment does not stand grinding. When ground at all fine the color is largely destroyed, the brilliant red being largely replaced by a yellow. The material can be obtained in the market mixed in japan, or oil; but we prefer to buy it dry. When received it is mixed with oil and japan by simply stirring, and not by grinding.

The pigment, when first made, is very dull, and after precipitation and washing, a treatment with sulphuric acid is essential in order to bring out the brilliant shade. The chemistry of this process or the change produced by this treatment is not understood—at least, we have never succeeded in finding any explanation of why sulphuric acid renders this material so much more brilliant in color than when first precipitated. The fact remains.

In view of the theoretical constitution of the pigment, it would seem that the limits of the specifications ought to be sufficiently wide, so that no difficulties would arise in securing material in the market which would fill the requirements; but some manufacturers almost universally fail to meet the specifications. We have had many shipments which did not contain enough of the normal lead chromate, and even some which were deficient in lead oxide. This is due largely to method of manufacture, but in general we have had very little difficulty in securing the pigment.

The method of analysis consists in treating a weighed sample with acetic acid and heat, which leaves the normal lead chromate undissolved. This is then filtered into a weighed Gooch crucible, and the amount obtained by weight after drying. The acetic acid solution contains the oxide of lead, and this is usually determined by titration with standard bichromate of potash. These figures should sum up, according to the specifications, 95 per cent., leaving only 5 per cent. for other substances. If this results, there is small probability of any adulterating material being used. A test, however, is always made by dissolving a fresh sample of the material in muriatic acid in presence of alcohol, which leaves barytes undissolved. The amount, if any is present, can be determined by filtration and subsequent weight.

Some experiments have been made to see whether scarlet lead chromate would bear dilution with inert material, in accordance with the principles which have been enunciated a number of times in previous articles of this series. Our experience with this pigment has not proven very satisfactory. The coloring and covering power of scarlet lead chromate is so meager that it does not seem to work well with any inert material which we have yet discovered. It is fair to say that 10 per cent. of barytes added does not interfere to any serious extent, but a 10 per cent. addition of inert material is so small that it is hardly worth while to attempt to use it. Such material—namely, scarlet lead chromate containing 10 per cent. of barytes—can be obtained in the market at a slightly lower price. As high as 50 per cent. of inert material affects the shade quite considerably. We are hardly satisfied yet, and our experiments are still in progress; but, so far as we have gotten, this pigment is apparently one of the few which will not bear much admixture with inert material.

The next specifications historically made on the Pennsylvania Railroad for paint materials were for freight car color. The use of freight car color on the road is very extensive, very large amounts of it being used every year, both for new work and for repairs. The specifications at present in force are the second revision. The first draft remained in force about one year, the second about one year, and the third, which is at present in force, about two and a half years. It seems probable that a new revision will be made possibly within the coming year, the principal probable change being to diminish the amount of oxide of iron required in the pigment. It is of course understood that, as knowledge increases on any given subject, the specifications are modified to meet the increase in knowledge, the constant aim being to secure the best pos-

sible results for the least money. The specifications are as follows:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Freight Car Color.

Freight car color will be bought in the paste form, and the paste must contain nothing but oil, pigment and moisture.

The proportions of oil and pigment must be as nearly as possible as follows:

Pigment, 75 per cent. by weight.

Oil, 25 per cent. by weight.

The oil must be pure raw linseed-oil, well clarified by settling and age. New process oil is preferred.

The pigment desired contains not over one-half per cent. of hygroscopic moisture, and has the following composition:

Sesquioxide of iron, 50 per cent. by weight.

Fully hydrated sulphate of lime or gypsum, 45 per cent. by weight.

Carbonate of lime, 5 per cent. by weight.

Samples of standard pigment showing shade will be furnished, and shipments will be required to conform strictly to standard. The shade of paint being affected by the grinding, the P. R. R. standard shade is that given by the dry sample sent, mixed with the proper amount of oil and ground, or better rubbed up in a small mortar with pestle until the paste will pass P. R. R. test for fine grinding. It is best to use fresh samples of the dry pigment for each day's testing. The comparison should always be made with the fresh material, and never with the paint after it has become dry. The comparison is easiest made by putting a small hillock of the standard paste and of that to be compared near each other on glass, and then laying another piece of glass on the two hillocks, and pressing them together until the two samples unite. The line where the two samples unite is clearly marked if they are not the same shade.

The paste must be so finely ground that when a sample of it is mixed with half its weight of pure raw linseed-oil, and a small amount of the mixture placed on a piece of dry glass, and the glass placed vertical, there will be no separation of the oil from the pigment for at least half an hour. The temperature affects this test, and it should always be made at 70° Fahrenheit. The sample under test runs down the glass in a narrow stream when it is placed vertical, and it is sufficient if the oil and pigment do not separate for an inch down from the top of the test.

Shipments will not be accepted which:

1. Contain less than 23 per cent. or more than 27 per cent. of oil.
2. Contain more than 2 per cent. of volatile matter, the oil being dried at 250° Fahrenheit, and the pigment dried in air not saturated with moisture at from 60° to 90° Fahrenheit.
3. Contain impure or boiled linseed-oil.
4. Contain in the pigment sulphate of lime not fully hydrated, less than 40 per cent. of sesquioxide of iron, less than 2 per cent. or more than 5 per cent. carbonate of lime, or have present any barytes, aniline colors, lakes or any other organic coloring matter, or any caustic substances, or any makeweight or inert material, which is less opaque than sulphate of lime.
5. Vary from shade.
6. Are not ground finely enough.
7. Are a liver, or so stiff when received that they will not readily mix for spreading.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of General Superintendent Motive Power, Altoona, Pa., November 9, 1888.

Taking up the points in the specifications in order as they come, we will say, the reason why the material is bought in the paste form is that the grinding of the paint is an art by itself, and requires a good plant and skill. It is, therefore, deemed advisable to put this work into the hands of parties who are fitted for it, instead of the company attempting to do this work itself. The mixing of paint for use, however, is wisely and properly varied by the conditions under which the paint is used; and accordingly the paint is bought in the paste form rather than ready mixed, the company leaving to its own employés the duty of proper mixing. It will be observed that only pigment, oil and moisture are allowed in the paste. The reason why japan or other materials are not allowed to be present is because japans differ very greatly with different makers, and consequently two batches of paint furnished the same shop by different makers would require different treatment in order to get the same results if japan was allowed to be present. On the other hand, nothing but pure raw linseed-oil being present, each master painter can use his own experience and judgment in the mixing, so as to obtain the best results. The quantities being definitely proportioned for the ingredients, gives the proper drying, and the proper results in service. The question of the amount of pigment and liquid will not be discussed in this article, since it properly belongs to the next one. We will only say here, therefore, that the percentages by weight given in these specifications are those which experience has indicated are necessary in order to secure a good paste.

The reason for preferring new process oil, which, as is well known, is made by treating the seeds with a solvent rather than by pressure alone, is that the new process oil is apt to contain less vegetable albumen and other impurities than from freshly made old process oil. It is not believed that linseed-oil obtained from the seeds by pressure alone and allowed to stand sufficiently long is not as good as new process oil, but there is a tendency in the trade to sell the oil soon after it is removed from the seeds; and we have many times found evidence of vegetable matter in the oil made by the old pressure process, which is not characteristic of freshly made new process oil.

The proportions of the various constituents of the pigment were at first decided on arbitrarily, as, when these specifications were first prepared, we had very little practical experience upon a good many points which have since been made the subject of definite test and experimentation. The amount of oxide of iron required in these specifications is probably higher than there is any need of, and, as hinted at above, it is probable that the next revision will diminish the amount required. Moreover, experiments indicate that abundantly good covering power is obtained with as low, perhaps, as 20 or 25 per cent. of the weight of the pigment oxide of iron, especially if the paint is finely ground. In reality oxide of iron is one of the very best of the cheap pigments. Its covering power is very high: its durability, so far as our experience goes, very great, and its price very low. Of course there are very wide differences in the shades of the different oxides, most of which are made by igniting copperas or igniting ochres. Some of these are of a rather disagreeable purplish red color; but a good oxide of iron of pleasing color is certainly a very valuable pigment, and we really know of none that is superior to it, all things considered. Some questions have arisen as to whether the oxide of iron is durable in the presence of oil, especially the oxides made by the ignition of the sulphate or copperas. It is on record in the books that it is believed oxide of iron, if it contains hydrated oxide, or contains free sulphuric acid, will deteriorate with moderate rapidity. Our own experience has not confirmed this statement, and we really have seen no positive information which points in the direction that oxide of iron is not a very durable pigment.

The reason why sulphate of lime is used as an inert material has already been discussed in the article preceding this one. The reason for a small amount of carbonate of lime is found in the fact that, as has already been hinted at, some of the iron pigments made from the ignited sulphate contain free sulphuric acid, the heat of ignition not being sufficient to drive it all off. We have made positive experiments which show that the presence of a small amount of free sulphuric acid mixed with the iron oxide retards the drying very greatly. We accordingly mix a small amount of carbonate of lime with the pigment, which satisfies the sulphuric acid, forming sulphate of lime, and we have found that this small amount of carbonate of lime facilitates drying very greatly.

A number of manufacturers have suggested the use of carbonate of lime or whiting in place of sulphate of lime in our freight car color as inert material. The reasons for preferring sulphate over carbonate have already been given; but we will say that we have experiments in progress to set this question finally at rest. Boards have been painted and exposed, in which the inert material is largely carbonate of lime, and also companion boards, in which the inert material is largely sulphate of lime. We hope within a year or two to have conclusions on this point. At present we are unable to say anything more positive than has previously been said.

The question of shade has caused no small amount of difficulty, and it is very common for manufacturers to remark, that our shade is a very difficult one to match. Our own experience is that the same remark may be made of every other shade, or, in other words, all shades are extremely difficult to match. The whole question of making duplicate shipments of exactly the same shade is extremely difficult; indeed, a very large number of conditions quite seriously affect the shade. Starting with the same paste, four or five different shades can be obtained in the finished work by using different percentages of japan and turpentine and oil in different portions of the paste, also by neglecting to stir the pot of paint during the application frequently enough, and, indeed, by allowing the mixed paint to stand a day or two and become skinned over, the shade is changed. It will be noted that the specifications call attention to the fact that the fineness of the grinding seriously affects the shade, and also to the fact that material which has been used one day should not be used the next in making the test. We have found by experience that both of these conditions quite seriously affect the standard shade. In the latter case, the shade is changed, due to the changed proportions of liquid and pigment, and also certain constituents seem to be removed more readily than others by the skin which is taken off. So positive are we of the difficulty connected with the exact matching of shades, that we do not hope to secure in successive shipments exact matches. It is astonishing many times how close the match is; but unless approximately the same pigments and the same proportions of inert materials are used by different parties, and by the same parties in different shipments, the shades will hardly ever be exactly the same. We accordingly allow ourselves a little lee-way in comparing shipments with the standard, rejecting if the shipment shows a marked difference from the standard. Considerable time has been spent in trying to devise some method of establishing limits of shade, outside of which shipments would not be accepted; but no feasible method has yet been obtained for making such comparisons, as we have not yet succeeded in getting any way of measuring how much one shade differs from another.

Our method of comparing shades has been criticised somewhat, many parties claiming that it is too severe to bring the two side by side under glass. We are quite well aware that this plan gives very close and accurate results; but we do not know of any better method than the one proposed. The whole question of shade is not free from difficulties, and, as many manufacturers have found, it is not a simple matter to make a shipment of paint look like a given sample. Some authorities on the subject of shade regard the matching of shade as a special gift, and that it is not at all possible for every one either to express an opinion on shades after they are placed side by side, or especially that all are not able to make such combinations as will produce the same shade.

The question of fine grinding was one which caused a good deal of study. At first we regarded the fineness of the pigment as the only consideration which should be studied; and accordingly, in our first specifications, a test as to whether the pigment would go through a certain mesh sieve was all the test we used for grinding. We found, however, that it was quite possible to have the pigment fine enough, and still, with a good mixer, to mix the paint so that it would pass this test for fineness without having gone through the mill at all. We accordingly tried to see if some test could not be devised which would decide positively whether the material had been ground or not. The test proposed, it will be observed, is based on the intimate mixture of the oil and pigment, the pigment being fine enough, so that practically the oil holds it up. It is well known that in a mixture of solid and fluid the tendency of the two to remain together is largely a function of the fineness of the solid. Familiar examples of this are dust in such a fine state of division that it floats in the air, and also clay or other substances in such a fine state of division that they are permanently sustained in water, keeping it cloudy or muddy for weeks. The test has thus far worked very satisfactorily, and with one or two possibilities of evasion seems to cover the ground very well. It is quite evident to any one that anything which adds to the viscosity of the oil would enable a coarser ground paint to pass the test. We of course are constantly on the lookout for anything of this kind. A small amount of caustic soda added to the oil, making a little bit of soap, would of course evade the test to a certain extent. This we check up by examining for soap in the mixed paint. The addition of small amounts of japan would also have the same tendency, and also the addition of small amounts of varnish or any other liquid mixed with the oil which would make it more viscous. These difficulties we are quite well aware may arise, and are constantly on the lookout for them. Those who have never experimented with the test will be astonished to see how readily the oil separates from the pigment if the material is at all coarse. It should be stated still further that if the pigment is of greater specific gravity than the standard pigment used for this paint, the tendency to separate will increase, so that the test as arranged for the standard freight car color is not universally applicable to all pigments. We think the principle is applicable, and it is only necessary to modify the conditions of the amount of oil added to the paste, or other conditions, in order to have the test universally applicable to the grinding of all paints in the paste form. Quite a large amount of water mixed with the oil, forming an emulsion, has the effect of rendering the oil more viscous, and for this reason, as well as for commercial reasons, it will be noted that the amount of volatile material, principally, of course, water, allowed in a shipment, is limited to 2 per cent.

The limits of oil allowed in the specifications—about 4 per cent.—are sufficiently wide, so far as our experience goes, so that shipments should never be rejected on account of having not enough oil, or too much. The question of the livering of the paint is one which is quite extensive, and we will therefore not take it up now, and closely connected with this is the point mentioned in the specifications of hydration of the sulphate of lime. We hope to give our experience with the livering of paint in a separate article. The reasons why for the causes which lead to the rejection of a shipment other than those mentioned are perhaps clearly evident from what has already been said.

In the next article we hope to finish the subject of "How to Design a Paint," and this will be followed by another, giving, if possible, in one article, our experience with the livering of paint and our specifications for Tuscan red.

(TO BE CONTINUED.)

THE PATENT CENTENNIAL.

THE centennial celebration of the establishment of the American Patent System began in Washington, according to the programme, on April 8, when the first public meeting took place in the Lincoln Music Hall. The President of the United States presided; upon the platform with him were the Secretary of the Interior, the Chief Justice of the United States, the Commissioner of Patents and a number of other distinguished gentlemen. The President made a brief opening address, and was followed by the Commissioner of Patents in a long and interesting speech on the Patent System. The next address was made by Senator O. H. Platt, Chairman of the Senate Committee on Patents, who gave a number of illustrations of the progress made in the past century, and was followed by Labor Commissioner Carroll D. Wright.

In the evening a special reception to inventors and manufacturers was given at the Patent Office by the Secretary of the Interior and the Commissioner of Patents. A large number of gentlemen and ladies were present, and the reception was much enjoyed.

On April 9 public meetings were held in the afternoon and evening, the first one being presided over by Hon. Frederick Fraley of Philadelphia, and the second by Professor S. P. Langley, Secretary of the Smithsonian Institution. Among the speakers were Mr. Edward Atkinson, Judge Samuel Blatchford, and Mr. O. Chanute, President of the American Society of Civil Engineers. Mr. Chanute referred to the progress in aerial navigation, and stated that several men of ability were now at work on a prob-

lem, the possibility being that practicable machinery would before long be in actual use.

On April 10, the day was given up to an excursion to Mt. Vernon, where an address was made by Dr. Toner, of Washington. This was the special anniversary day, being the hundredth anniversary of the signing of the first American patent. In the evening another public meeting was held, at which Professor Alexander Graham Bell presided. Addresses were made by Professor Gray, Dr. Brackett, and others.

This necessarily brief account can give but a few of the prominent features of the celebration. The Executive Committee and the Local Committee made admirable arrangements for the reception of visitors and the celebration was much enjoyed by all present, among the special features being the reception at the White House, that at the Patent Office, and the excursion to Mt. Vernon.

AMERICAN ASSOCIATION OF INVENTORS AND MANUFACTURERS.

Part of the proceedings at the Patent Centennial included the formation of a permanent association to care for the interests of inventors and manufacturers. A National Committee had been appointed, representing all the States, and the first meeting was held April 8, which was chiefly devoted to preliminary discussion. A special committee was appointed and a general meeting of inventors and manufacturers was called, which was held in the morning of April 9, at which a committee was prepared to submit a plan of organization.

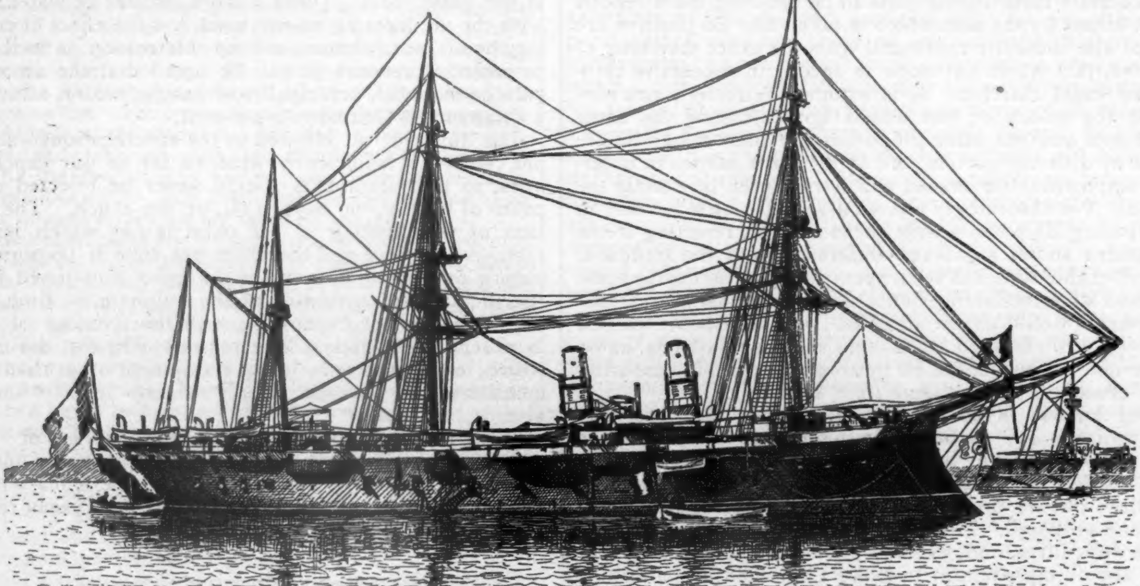
On April 10 another meeting was held, at which this committee submitted a constitution and by-laws for the proposed Association, the objects of which was stated as follows:

"The promotion of progress in the useful arts; the diffusion of practical, scientific, and legal information respecting inventions; the encouragement of favorable and the discouragement of unfavorable laws respecting property in patents; the co-operation of foreign inventors for reciprocal regulations under foreign patent systems, and the proper, just and adequate protection of the rights of American inventors authorized by the Constitution of the United States."

The report of the committee was thoroughly discussed. Some changes were made in the proposed constitution, and it was finally adopted as amended. The organization was completed by electing the following officers: President, Dr. R. J. Gatling, Hartford, Conn. Vice-Presidents, Gardner G. Hubbard, Washington; Thomas W. Shaw, Philadelphia; William A. Anthony, Manchester, Conn.; Benjamin Butterworth, Cincinnati. Secretary, Professor J. Elfreth Watkins, Washington. Treasurer, Marvin C. Stone, Washington. Directors, Charles F. Brush, Cleveland, O.; Professor R. H. Thurston, Ithaca, N. Y.; Professor Otis T. Mason, Washington; Oberlin Smith, Bridgeton, N. J.; David S. Weems, Baltimore; John H. Bartlett, Roanoke, Va.; F. E. Sickles, St. Louis; John Y. Smith, Pittsburgh, Pa.; David W. Smyth, Manchester, N. H.; R. S. Munger, Birmingham, Ala. The constitution, etc., will be published later.

Foreign Naval Notes.

THE results obtained in the official trials of the Fiske range finder, both in France and Italy, were most satisfactory to the commissions of officers who tested it. In France the trials were held on board *Le Formidable*, the flagship of the Mediterranean fleet, and they comprised a careful series of observations taken both under way and at anchor at Cannes and Toulon. In Italy the range finder was mounted and tried on the old *Terrible*. The results in both cases showed very small percentages of error, notwithstanding the restricted base lines on the vessels used.



THE FRENCH CRUISER "SFAX."

The *Rainbow*, the second of three second-class cruisers which are being built for the British Government by Messrs. Palmer & Company, was successfully launched early in April. She has a displacement of 3,400 tons; length, 300 ft.; breadth, 43 ft., and draft, 16 ft. 6 in. Her engines will develop 9,000 H.P., sufficient to propel her under natural draft at a speed of 18 knots. Her armament will consist of two 6-in. and six 4.7-in. rifled breech-loading guns, and nine quick-firing guns.

The French Navy Department has asked for appropriations for next year amounting to $45,532,858, an increase of $667,926 over the present year.

The trials of the Elswick 6-in. quick-firing gun and mounting were completed on board the *Kite*, at Portsmouth, England, last week. Two hundred and sixty rounds have now been fired from this gun on the same mounting, and there does not appear to be the slightest sign of wear in any of the working parts. The rapidity and ease with which one man can elevate and train the gun and mountings, the weight of which complete is 17 tons, is surprising; and it says a great deal for the crew, as well as for the gun, mounting, and ammunition, that 260 rounds have been fired, almost all against time, without the slightest hitch occurring. It should also be specially noted that, of this last series of 100 rounds, 80 cartridges were fired for the second time. But this feature has been brought out, perhaps, more prominently by trials which have been carried out by a similar 6-in. quick-firing gun by the military authorities at Shoeburyness, where cartridges have been fired as many as 16 times.

Engineering thinks that these exhaustive trials, giving such successful results, should convince others besides the English Government of the efficiency of the Elswick system.

A FRENCH CRUISER.

The accompanying illustration, from *Le Yacht*, shows the French cruiser *Sfax*, which is considered one of the finest vessels of her class in the French Navy. She is built of steel, and was launched in 1884.

The *Sfax* is 288.6 ft. long, 49.2 ft. beam, 25 ft. draft, and 4,500 tons displacement. Her compound engines drive twin-screws, and have developed 6,522 H.P., giving the ship a speed of 16.7 knots per hour.

The chief protection consists of an armored deck of steel, 1.6 in. thick, extending the whole length of the ship. The armament consists of six 16-cm. (6.3-in.) guns, ten 14-cm. (5.5-in.) guns, 10 revolving cannon, and five torpedo-tubes.

Like most French cruisers, the *Sfax* is heavily masted, and can carry a considerable area of sails. Her crew consists of 473 officers and men.

THE ESSENTIALS OF MECHANICAL DRAWING.

BY M. N. FORNEY.

(*Continued from page* 181.)

CHAPTER XI.

CURVES.

ARCS OF CIRCLES.

THE circles and portions of circles thus far described have been of such dimensions and located in such positions, that there has been no difficulty in drawing them with a pair of ordinary compasses. It happens, however, at times that the center

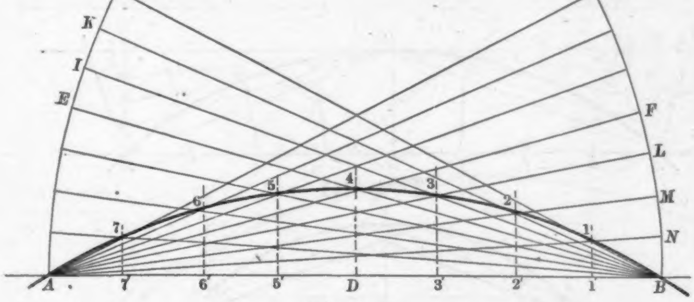


Fig. 241.

of an arc of a circle is inaccessible, or the radius is so long that it is impracticable to draw an arc with the instrument named, or even with a beam compass. We may, for example, have:

PROBLEM 65. *To describe a circle passing through three given points, when the center is not available.*

* *First Method.*—Let A 4 and B, fig 241, be the three points. From A as a center with $A\ B$ as a radius describe an arc, $B\ H$, and from B, with the same radius, describe $A\ G$. Through the third point 4 draw the lines A 4 F and B 4 E, intersecting the arcs at E and F. Divide $A\ E$ and $B\ F$ into any number of equal parts, and set off a series of equal parts of the same length on the upper portions $E\ G$ and $F\ H$ of the arcs beyond the points E and F. Draw straight lines $B\ I$, $B\ K$ and $B\ G$ to the divisions in $A\ G$; and $A\ L$, $A\ M$, $A\ N$, etc., to the division on $B\ H$; the successive intersections, 1, 2, and 3, of these lines are points in the circle required, between B and 4. Similar points between A and 4 may be laid out in the same way, and the required curve, A 4 B, may then be drawn by hand with a pencil through the points thus laid out. In inking in this curve, the student will find that it is very difficult to draw it with the precision and smoothness that is possible when drawing instruments are used, and few draftsmen ever acquire the skill which will enable them to draw curves by hand with the accuracy and definiteness which is required to make a drawing look neat and workmanly. When instruments cannot be used it is therefore best to make or use a "*templet.*" As this will be essential in many such cases, the method of making such an implement will be described.

The student should provide himself with a piece of straight-grained white pine, clear of sap of resin, and about $\frac{3}{16}$ in. thick, planed smooth on both sides and on one edge, so as to make the latter straight. After the points of the curve have been laid down on paper, draw the line $A\ B$ on the piece of wood at a little distance from and parallel to its straight edge. The points of the curve may then be laid out on the wood, as already described, or it can be done more conveniently by first drawing on the paper "*ordinates*" or perpendicular lines, 1 1′, 2 2′ 3 3′, etc., from the points 1, 2, 3, etc., to $A\ B$. These should be laid off with a pair of dividers from the perpendicular D 4, drawn on the wood midway between A and B. The distance 1′ 1, 2′ 2, 3′ 3, etc., should then be transferred from the paper to the ordinates on the wood, and the curve can be drawn with a pencil as accurately as possible through the points 1, 2, 3, etc., thus laid down. Then with a sharp knife cut away the wood from the outside of the curve *near* to the line required, and bring it exactly up to the mark by means of a fine file, or fine sandpaper, or both. A half-round file is best for this, as one side of it can be used to finish up concave curves. In using the sandpaper, lay a smooth sheet or piece of it on the drawing-board, and rub the edge of the templet on the paper, being careful to hold the slip of wood so that its sides will be perpendicular to the surface of the paper. This templet may then be used as a ruler for drawing the curve with a pen.

A great variety of templets or "*curves*," as they are called, made of hard rubber or wood, are now sold by the dealers in drawing instruments and materials. These are intended for drawing different objects, such as ships, railroad curves, etc. For drawing the latter, sets of circular "curves," of varying radii, are sold, which all mechanical draftsmen will find very useful if they can afford to supply themselves with them. The cost of a set of 10 of these is given in the catalogue of a prominent dealer at $7.75; sets of 17, $13.25; and 40, $28.

Second Method for the solution of PROBLEM 65.—Let A 4 B, fig. 242 be the given points; draw $A\ B$, A 4, D 4 and $e\ f$ through 4 and parallel to $A\ B$. Divide A 4 into a number of equal parts, a, b, c, 4, and from 4 describe arcs through these points to meet $e\ f$. Divide the arc $A\ e$ into the same number of equal parts, and draw straight lines from 4 to the points of division. The intersection of these lines successively with the arcs 1, 2, 3, etc., are points in the circle, which may be filled as before.* For inking the curve in, a templet should be constructed as described above.

Third Method.—Let A 4 B, fig. 243, be the required points. Draw the chord $A\ D\ B$ and h 4 i through 4 and parallel to $A\ D\ B$. Bisect $A\ D\ B$ at D and erect the perpendicular D 4; join A 4 and B 4; draw $A\ h$ perpendicular to A 4 and $B\ i$ perpendicular to B 4. Erect also $A\ n$ and $B\ n$ perpendicular to $A\ D\ B$; divide $A\ D\ B$ and $h\ i$ into any number of equal parts—in this case eight—and draw the lines $d\ d'$, $e\ e'$, $f\ f'$, etc., and divide the lines $A\ n$, $B\ n$ each into half the number of equal parts in $A\ D\ B$; draw lines from 4 to each division in the lines $A\ n$ and $B\ n$, and the points of intersection, 1, 2, 3, 4, etc., with the former lines, will be points in the required curve.†

PROBLEM 66. *To describe an arc or segment*‡ *of a circle of a large radius.*

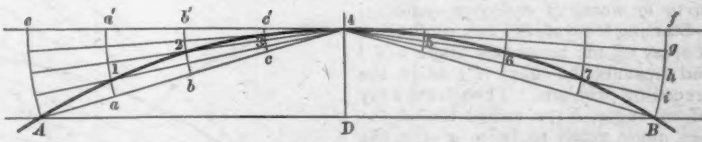


Fig. 242.

Let $d\ c$, fig. 244, be the chord of the arc and $b\ o$ its rise or versed sine. Then with wood or other suitable material con-

* The two following solutions are from "The Engineer's and Mechanic's Drawing Book."

* The second method is not perfectly true, but sufficiently so for arcs less than one-fourth of a circle. When the middle point is equally distant from the extremes, the vertical $C\ D$ is the *rise* or *versed sine* of the arc. This problem is serviceable for setting out circular arcs of large radius, as for bridges of very great span, when the center is unavailable; and for the outlines of bridge-beams, steam-engine beams, connecting-rods and the like.

† This and the following problem are from the "Engineer's and Mechanic's Pocket Book," by Charles H. Haswell.

‡ The word segment means a portion. A segment of a circle is a portion of a circle.

struct a triangle, *A b C*, of which the sides *A b* and *b C* are slightly longer than the chord *d c*, and whose apex, *b*, will coincide with the point *b* in the circle, and the points *d* and *c* will coincide with the sides *A b* and *b C*. At each end of the chord *d c* insert a pin, and at *b* attach a tracer (as a pencil or sharp point); move the triangle against the pins as guides, and the tracer will describe the arc required.

PROBLEM 67. *To lay out a circular curve by means of tangential angles.*

If from any point, *A*, fig. 245, on a line *A a*, equal angles *a A b*, *b A c*, *c A d*, etc., are laid off, and lines *A b*, *A c*, *A d*, etc., are drawn; then if with any distance, as *A* 1 for a chord, we step off from *A a*, point 1, on *A b*, and with the same chord lay off another point, 2, from 1 on *A c*, and if in a similar way the points 3, 4, 5, etc., are laid off on *A d*, *A e*, *A f*, etc., then these points will be situated in a circular curve, the radius of which depends upon the angles and the length of the chords. The curve will also be tangent to the straight line *A a* at *A*, the place of beginning. Consequently the angle *a A b* is called the "*tangential angle*," and as the others are all equal to it, they are also called tangential angles. This is one of the methods employed for laying off railroad curves, the angles being measured with instruments constructed for the purpose. Elaborate tables have been calculated, which give the radii of curves for given angles and chords. The following table has been calculated for a chord equal to 1, so that it can be used for any length of chord that may be employed. Thus 1 may represent one-eighth of an inch, one inch, one foot or one hundred feet; but if the chords are measured in fractions of an inch, inches, feet or hundreds of feet, the radii of the curves are also given in the same fractions, or in inches, feet or hundreds of feet.

In the first column the tangential angles are given, in the second the "*deflection angles*," which will be explained hereafter, and in the third the radii of curves laid off with such angles and chords = 1. Thus, in fig. 245 the tangential angles *a A b*, *b A c*, etc., are 5 degrees and the chords *A* 1, 1 2, 2 3, etc., are equal to ½ in.; consequently the radius of the curve is given in half inches, and is equal to $\frac{11.463}{2} = 5.731$ in. If the chord used had been an inch long, the radius of the curve, with tangential angles of 5 degrees, would have been equal to 11.463 in.; if the chord had been equal to 1 ft., the radius would be 11.463 ft. From the table, then, we can readily ascertain what the radius will be for any angle of deflection and any chord.

If for any reason—as happens very often in laying out railroad curves—a curve cannot be completed from one point, as *A*, then it can be continued from any other point, as 5, by extending the chord 5 6 to *j*, and laying off angles *j* 5 *k*, *k* 5 *l*, *l* 5 *m*, etc., from 5 *j*, and continuing as already explained; or a curve of greater or lesser radius may be drawn from 5, as may be desired.

PROBLEM 68. *To lay out a circular curve by means of deflection angles.*

Starting from *A*, fig. 246, on the line *A a*, lay off the tangential angle *a A b* and measure the chord *A* 1 as in the preceding problem. Then from 1 lay off an angle, *b* 1, *c* called the *deflection angle*, equal to twice *a A b*, the tangential angle, and measure the chord 1 2 on 1 *c*. Then 2 will be a second point in the curve. Proceed in the same way, and lay off deflection angles from the successive points 2, 3, 4, 5, etc., and measure the chords on the lines 2 *c*, 3 *d*, 4 *e*, etc., and the points thus established will be in the required curve. It must be remembered that the deflection angles are always twice the tangential angles. In the table the tangential angles are given in the first column, the deflection angles in the second and the radii of curves for chords of 1 in the third column.*

TABLE OF RADII—CHORD, ONE FOOT.

Tangential Angle.	Angle of Deflection.	Radius in Feet.	Tangential Angle.	Angle of Deflection.	Radius in Feet.	Tangential Angle.	Angle of Deflection.	Radius in Feet.
		Ft.			Ft.			Ft.
0° 0½′	0° 1′	3437·61	0° 22′	0° 44′	78·13	0° 57′	1° 54′	30·157
1′	2′	1718·80	22½′	45′	76·39	58′	1° 56′	29·637
1½′	3′	1145·87	23′	46′	74·73	59′	1° 58′	29·135
2′	4′	859·40	23½′	47′	73·14	1° 0′	2° 0′	28·649
2½′	5′	687·52	24′	48′	71·62	1° 1′	2° 2′	28·180
3′	6′	572·93	24½′	49′	70·16	1° 2′	2° 4′	27·725
3½′	7′	491·09	25′	50′	68·76	1° 3′	2° 6′	27·285
4′	8′	429·70	25½′	51′	67·41	1° 4′	2° 8′	26·859
4½′	9′	381·97	26′	52′	66·11	1° 5′	2° 10′	26·446
5′	10′	343·78	26½′	53′	64·86	1° 6′	2° 12′	26·045
5½′	11′	312·52	27′	54′	63·66	1° 7′	2° 14′	25·656
6′	12′	286·48	27½′	55′	62·51	1° 8′	2° 16′	25·279
6½′	13′	264·44	28′	56′	61·39	1° 9′	2° 18′	24·913
7′	14′	245·55	28½′	57′	60·31	1° 10′	2° 20′	24·557
7½′	15′	229·18	29′	58′	59·27	1° 11′	2° 22′	24·211
8′	16′	214·86	29½′	59′	58·27	1° 12′	2° 24′	23·875
8½′	17′	202·22	30′	1° 0′	57·30	1° 13′	2° 26′	23·548
9′	18′	190·98	31′	1° 2′	55·45	1° 14′	2° 28′	23·230
9½′	19′	180·94	32′	1° 4′	53·72	1° 15′	2° 30′	22·920
10′	20′	171·89	33′	1° 6′	52·09	1° 16′	2° 32′	22·619
10½′	21′	163·70	34′	1° 8′	50·56	1° 17′	2° 34′	22·325
11′	22′	156·26	35′	1° 10′	49·11	1° 18′	2° 36′	22·039
11½′	23′	149·47	36′	1° 12′	47·75	1° 19′	2° 38′	21·760
12′	24′	143·24	37′	1° 14′	46·46	1° 20′	2° 40′	21·488
12½′	25′	137·51	38′	1° 16′	45·23	1° 21′	2° 42′	21·223
13′	26′	132·22	39′	1° 18′	44·07	1° 22′	2° 44′	20·964
13½′	27′	127·32	40′	1° 20′	42·97	1° 23′	2° 46′	20·711
14′	28′	122·78	41′	1° 22′	41·92	1° 24′	2° 48′	20·465
14½′	29′	118·54	42′	1° 24′	40·93	1° 25′	2° 50′	20·224
15′	30′	114·59	43′	1° 26′	39·97	1° 26′	2° 52′	19·989
15½′	31′	110·90	44′	1° 28′	39·07	1° 27′	2° 54′	19·759
16′	32′	107·43	45′	1° 30′	38·20	1° 28′	2° 56′	19·535
16½′	33′	104·17	46′	1° 32′	37·37	1° 29′	2° 58′	19·315
17′	34′	101·11	47′	1° 34′	36·57	1° 30′	3° 0′	19·101
17½′	35′	98·22	48′	1° 36′	35·81	1° 31′	3° 2′	18·891
18′	36′	95·49	49′	1° 38′	35·08	1° 32′	3° 4′	18·686
18½′	37′	92·91	50′	1° 40′	34·38	1° 33′	3° 6′	18·485
19′	38′	90·47	51′	1° 42′	33·70	1° 34′	3° 8′	18·288
19½′	39′	88·15	52′	1° 44′	33·06	1° 35′	3° 10′	18·096
20′	40′	85·94	53′	1° 46′	32·43	1° 36′	3° 12′	17·907
20½′	41′	83·85	54′	1° 48′	31·83	1° 37′	3° 14′	17·723
21′	42′	81·85	55′	1° 50′	31·25	1° 38′	3° 16′	17·542
21½′	43′	79·95	56′	1° 52′	30·70	1° 39′	3° 18′	17·365

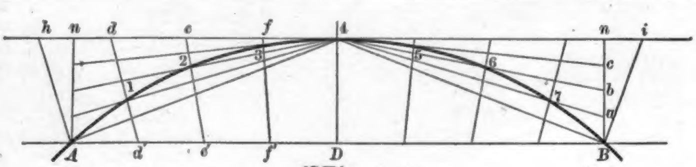


Fig. 243.

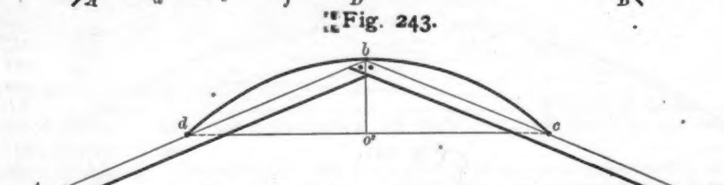


Fig. 244.

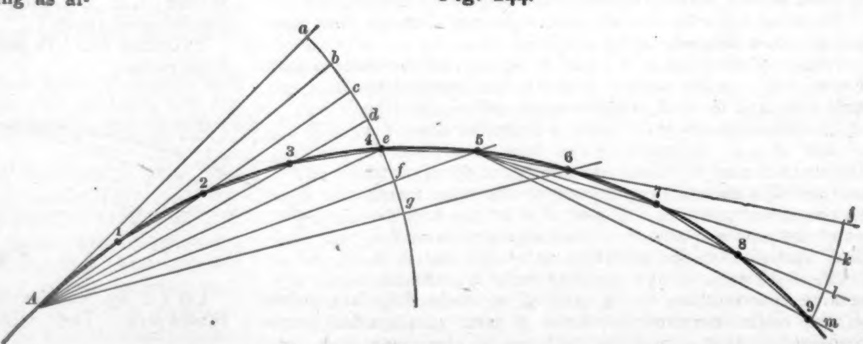


Fig. 245.

THE ELLIPSE.

An ellipse is an oval-shaped curve, fig. 247, which has the characteristic property that the sum of the distances of any point in the curve from two points, *a* and *b*, called the *foci*, is

* Students who wish to study this subject still further are advised to read "The Field Practice of Laying out Circular Curves for Railroads," by John C. Trautwine, C.E.

TABLE OF RADII—CHORD, ONE FOOT. (*Continued.*)

Tangential Angle.	Angle of Deflection.	Radius in Feet.	Tangential Angle.	Angle of Deflection.	Radius in Feet.	Tangential Angle.	Angle of Deflection.	Radius in Feet.
		Ft.			Ft.			Ft.
1° 40′	3° 20′	17·191	2° 57½′	5° 55′	9·688	6° 15′	12° 30′	4·593
1° 41′	3° 22′	17·021	3° 0′	6° 0′	9·554	6° 22½′	12° 45′	4·503
1° 42′	3° 24′	16·854	3° 2½′	6° 5′	9·423	6° 30′	13° 0′	4·417
1° 43′	3° 26′	16·691	3° 5′	6° 10′	9·296	6° 37½′	13° 15′	4·334
1° 44′	3° 28′	16·530	3° 7½′	6° 15′	9·172	6° 45′	13° 30′	4·254
1° 45′	3° 30′	16·373	3° 10′	6° 20′	9·051	6° 52½′	13° 45′	4·177
1° 46′	3° 32′	16·218	3° 12½′	6° 25′	8·934	7° 0′	14° 0′	4·103
1° 47′	3° 34′	16·067	3° 15′	6° 30′	8·819	7° 7½′	14° 15′	4·031
1° 48′	3° 36′	15·918	3° 17½′	6° 35′	8·708	7° 15′	14° 30′	3·962
1° 49′	3° 38′	15·772	3° 20′	6° 40′	8·599	7° 22½′	14° 45′	3·895
1° 50′	3° 40′	15·629	3° 22½′	6° 45′	8·493	7° 30′	15° 0′	3.831
1° 51′	3° 42′	15·488	3° 25′	6° 50′	8·390	7° 37½′	15° 15′	3·768
1° 52′	3° 44′	15·350	3° 27½′	6° 55′	8·289	7° 45′	15° 30′	3.708
1° 53′	3° 46′	15·214	3° 30′	7° 0′	8·190	7° 52½′	15° 45′	3·649
1° 54′	3° 48′	15·081	3° 32½′	7° 5′	8·094	8° 0′	16° 0′	3·593
1° 55′	3° 50′	14·950	3° 35′	7° 10′	8·000	8° 15′	16° 30′	3·485
1° 56′	3° 52′	14·821	3° 37½′	7° 15′	7·908	8° 30′	17° 0′	3·383
1° 57′	3° 54′	14·694	3° 40′	7° 20′	7·818	8° 45′	17° 30′	3·287
1° 58′	3° 56′	14·570	3° 42½′	7° 25′	7·731	9° 0′	18° 0′	3·196
1° 59′	3° 58′	14·447	3° 45′	7° 30′	7·645	9° 15′	18° 30′	3·111
2° 0′	4° 0′	14·327	3° 47½′	7° 35′	7·561	9° 30′	19° 0′	3·029
2° 2½′	4° 5′	14·034	3° 50′	7° 40′	7·479	9° 45′	19° 30′	2·953
2° 5′	4° 10′	13·754	3° 52½′	7° 45′	7·399	10° 0′	20° 0′	2·879
2° 7½′	4° 15′	13·484	3° 55′	7° 50′	7·320	10° 30′	21° 0′	2·744
2° 10′	4° 20′	13·225	3° 57½′	7° 55′	7·243	11° 0′	22° 0′	2·620
2° 12½′	4° 25′	12·976	4° 0′	8° 0′	7·168	11° 30′	23° 0′	2·508
2° 15′	4° 30′	12·736	4° 7½′	8° 15′	6·951	12° 0′	24° 0′	2·405
2° 17½′	4° 35′	12·504	4° 15′	8° 30′	6·747	12° 30′	25° 0′	2·310
2° 20′	4° 40′	12·281	4° 22½′	8° 45′	6·554	13° 0′	26° 0′	2·223
2° 22½′	4° 45′	12·066	4° 30′	9° 0′	6·373	13° 30′	27° 0′	1·142
2° 25′	4° 50′	11·858	4° 37½′	9° 15′	6·201	14° 0′	28° 0′	2·067
2° 27½′	4° 55′	11·657	4° 45′	9° 30′	6·038	14° 30′	29° 0′	1·997
2° 30′	5° 0′	11·463	4° 52½′	9° 45′	5·884	15° 0′	30° 0′	1·932
2° 32½′	5° 5′	11·275	5° 0′	10° 0′	5·737	15° 30′	31° 0′	1·871
2° 35′	5° 10′	11·093	5° 7½′	10° 15′	5·597	16° 0′	32° 0′	1·814
2° 37½′	5° 15′	10·917	5° 15′	10° 30′	5·464	16° 30′	33° 0′	1·760
2° 40′	5° 20′	10·747	5° 22½′	10° 45′	5·338	17° 0′	34° 0′	1·710
2° 42½′	5° 25′	10·582	5° 30′	11° 0′	5·217	17° 30′	35° 0′	1·663
2° 45′	5° 30′	10·421	5° 37½′	11° 15′	5·101	18° 0′	36° 0′	1·618
2° 47½′	5° 35′	10·266	5° 45′	11° 30′	4·991	18° 30′	37° 0′	1.576
2° 50′	5° 40′	10·115	5° 52½′	11° 45′	4·885	19° 0′	38° 0′	1·536
2° 52½′	5° 45′	9·969	6° 0′	12° 0′	4·783	19° 30′	39° 0′	1·498
2° 55′	5° 50′	9·826	6° 7½′	12° 15′	4·686	20° 0′	40° 0′	1·462

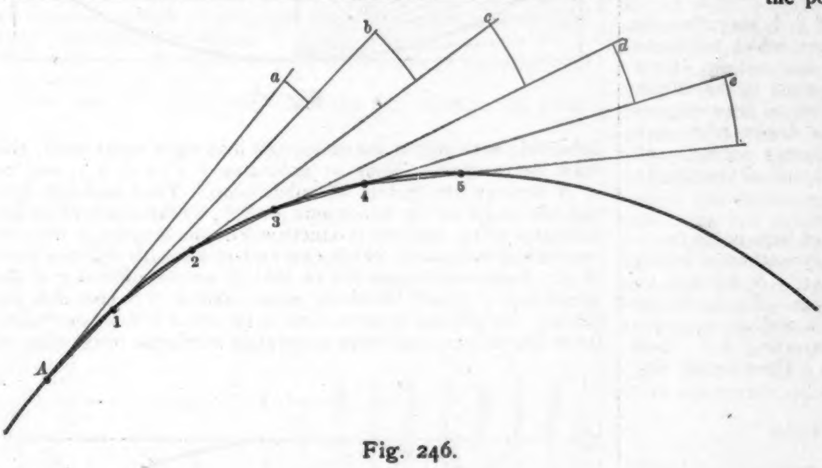


Fig. 246.

equal to the long diameter, *C D*, called the ***major*** or ***conjugate axis***. Thus, in fig. 247, the distance $a\,c + c\,b = C\,D$, and $a\,e + e\,b = C\,D$. If we measure the distance of any point of the curve from the two foci, and add these distances together, their sum will be equal to the major axis.

Ellipses also have the peculiarity that the nearer their two axes are of the same length, the more the curve approximates to a circle, and it will coincide with a circle if the axes are of equal length; on the other hand, if the minor axis is shortened in proportion to the major axis, the length of the figure will approximate to a straight line, and will become such a line if the short diameter is infinitely small. Ellipses may, therefore, be round or flat, but they always have the properties described above.

PROBLEM 69. *To draw an ellipse with a string and pencil.*

Lay down the major axis *C D*, fig. 247, and bisect it at *E*, and draw the minor axis *c d* through *E* and perpendicular to *C D*. To find the foci, take half the length of *C D*, and from *c* or *d* as a center, draw arcs intersecting *C D* at *a* and *b*. The points of intersection will be the foci. Take a string whose length is just equal to *C D*, and drive nails or pins in the foci and in *c* or *d*. Pass the string around the three pins and tie it to *a* and *b*. Take out the pin at *c* and substitute a pencil, and draw the string tight. The pencil may then be moved along inside of the loop so as to trace an ellipse on the paper. It is difficult to draw accurately or neatly by this method, especially if the ellipses are small.

PROBLEM 70. *To lay off an ellipse with a straight edge.*

Draw the major and minor axes *A B* and *C D*, fig. 248. Then on a thin wooden straight edge, slip of stiff paper, or card *s s*, mark lines *e* and *g*, whose distance apart, *e g*, is equal to *O B*, or half the major axis, and make *g f* equal to *O C*, or half the minor axis. Move the straight edge so that the points *e* and *f* will coincide with the *A B* and *C D*, and then mark the point *g*, which will be in the curve of the ellipse. Move the straight edge into other positions, being careful that *e* and *f* always coincide with *A B* and *C D*, and from *g* mark as many points in the curve as may be desirable. It can then be drawn through these points, as has been explained.

PROBLEM 71. *To lay out the curve of an ellipse, the two axes being given.*

Draw the two axes *A B* and *C D*, fig. 249, at right angles to each other. From their point of intersection, *E* as a center and one-half the short axis, describe a circle, *C c*, *F D*; and also from *E*, with half the major axis as a radius, draw another circle, *A H B I*. Divide the larger circle into any number of equal parts—sixteen in this instance. From the center *E* draw radii through the points of subdivision and cutting the inside circle. From the points of intersection of these

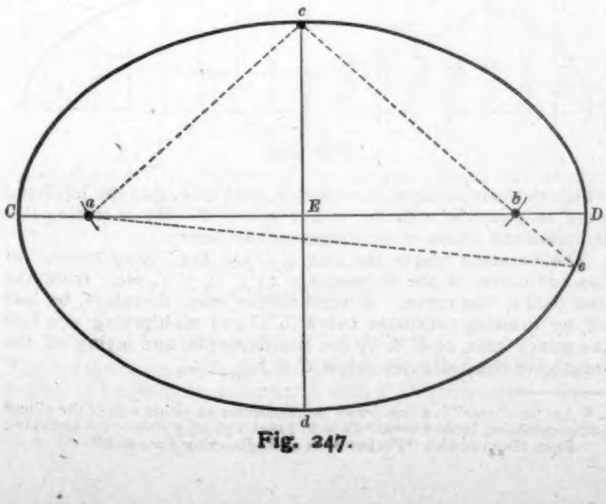


Fig. 247.

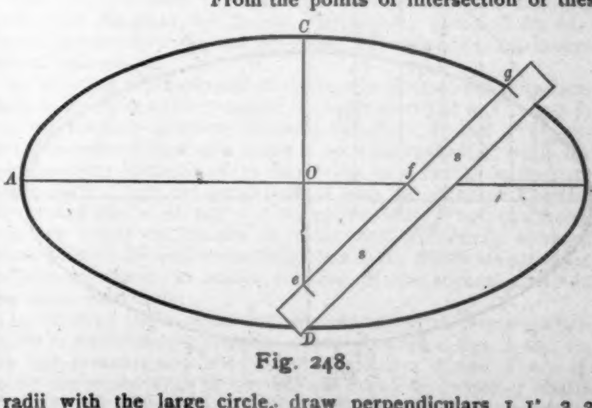


Fig. 248.

radii with the large circle, draw perpendiculars 1 1′, 2 2′, 3 3′, etc., and from the points of intersection, 1′, 2′, 3′, etc., with the small circle draw horizontal lines, 1′ 1″, 2′ 2″, 3′ 3″,

etc.; then the points of intersection, 1", 2", 3", etc., of these lines will be points in the ellipse, which can be drawn by a templet in the same way as has been described for drawing arcs of circles.

The curve of the ellipse may be drawn through the points thus laid down with a very close approximation to correctness by finding centers *a* and *b* by trial on the major axis, from which arcs of circles may be drawn which will coincide very closely to the ends of the ellipse from 3" to 5" and 11" to 13". In the same way centers may be found at *c* and *d* on the minor axis, extended from which portions of the top and bottom of the

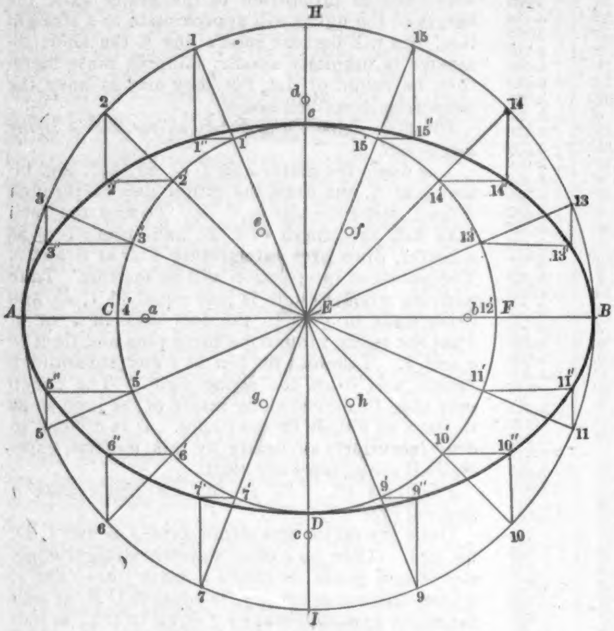


Fig. 249.

ellipse can be drawn. Other centers, *e f g h*, may then be found by trial from which arcs may be drawn, which will unite those which represent the ends and the top and bottom of the ellipse, and which will pass through the points in the ellipse which have been laid down. It is impossible to draw ellipses correctly with compasses, and at best when drawn with such instruments, the curves are only approximately correct, and are decidedly inferior to true ellipses in point of regularity and beauty of contour.

PROBLEM 72. *To lay out an ellipse.*

The fact that the sum of the distances of any point in an ellipse is equal to its major axis gives an easy method of laying off any number of points in the ellipse. Let *A B*, fig. 250, be the major and *C D* the minor axis in an ellipse. To lay off the two foci, take *A E* = one-half of *A B* as a radius, and from *C* or *D* as a center draw arcs at *e* and *f* intersecting *A B*; then these points of intersection will be the foci. Then lay off any

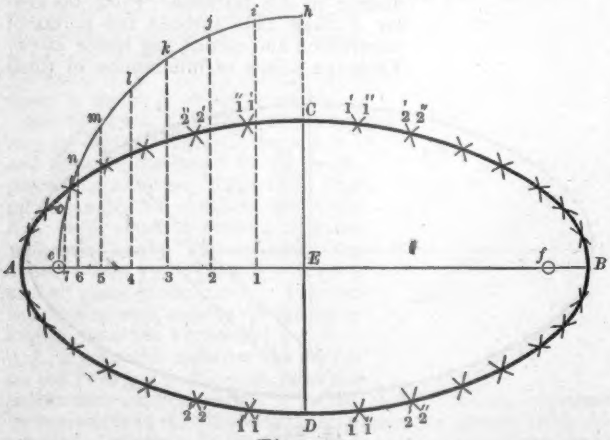


Fig. 250.

number of points, 1, 2, 3, 4, 5, 6, 7, between the center *E* and the focus *e*, and with *B* 1 as a radius and *e* and *f* as centers describe arcs 1', 1', 1', 1'; and with 1 *A* as a radius and from the same centers describe arcs 1", 1", 1", 1", intersecting 1'—1'. The points of intersection will be points in the ellipse. Then with *B* 2 and *A* 2 as radii proceed in the same manner, which will give other points in the ellipse, and by taking successively *B* 3, *A* 3, *B* 4, *A* 4, etc., as radii still other points may be laid down. The curve of the ellipse can then be drawn either with a template or compasses, as has been described.

It will be found desirable that the points laid off between *e* and *E* should be nearer together next to *e* than they are next to *E*. For this reason it is well to draw a quarter circle *e h* from the center *E* with a radius *E e*. The arc *e h* should then be divided into any number of equal parts. From the points of subdivision *i j k*, etc., draw perpendicular lines *i* 1, *j* 2, *k* 3, etc., to *A g*. The points 1, 2, 3, etc., will thus be nearer together as they approach *e*.

PROBLEM 73. *Another method of laying out an ellipse.*

Having drawn the major and minor axes *A B* and *C D*, fig. 251, construct a rectangle *f g h i*, whose sides are parallel to the axes and pass through their extremities, *A*, *C*, *B*, *D*. Divide *A E* and *A F* into the same number of equal parts, 1, 2, 3, 4, 5, and 1', 2', 3', 4', 5'. Draw lines from *D* through 1, 2, 3, etc., to meet lines from *C* through 1', 2', 3', etc., on *A F*. Their points of intersection, 1", 2", 3", etc., are points in the ellipse. The other portions of it can be laid out in a similar way. This method can be advantageously employed for laying off a semi-elliptical arch.

PROBLEM 74. *To lay off an ellipse by ordinates.**

Draw *A B*, fig. 252, the major axis of the ellipse, and 8" 8, one-half the minor axis, perpendicular to *A B* at its middle point, 8.

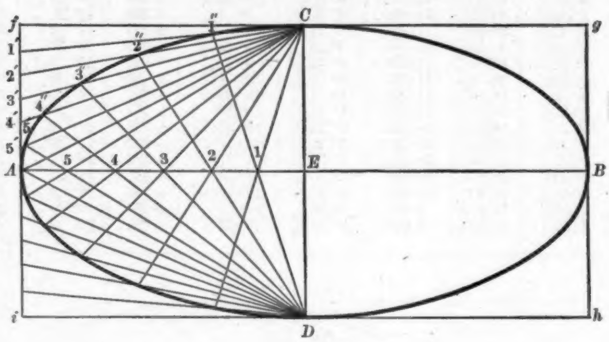


Fig. 251.

Subdivide each half of the major axis into eight equal parts, and draw perpendicular lines or ordinates 1 1', 2 2', 3 3', etc., to *A B* through the points of subdivision. Then multiply one-half the length of the minor axis, or 8 8", by the numbers on the ordinates in fig. 252; the products will be the lengths of the corresponding ordinates, which can be laid off with dividers from *A B*. Similar ordinates can be laid off on the right side of the minor axis 8" 8 and below the major axis *A B* to complete the ellipse. In practice it saves time to lay off *A* 8" 8, or one-quarter of the ellipse, and make a template for it, the lower edge of

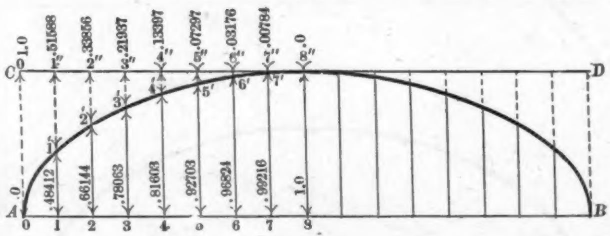


Fig. 252.

which is made straight, to coincide with *A* 8, and the left-hand edge to coincide with the minor axis 8" 8. By reversing this template the whole of the ellipse can be drawn.

The numbers above the line *C D* are the "*complements*" of the ordinates or the distances 1" 1', 2" 2', 3" 3', etc., from the line *C D* to the curve. A semi-ellipse may, therefore, be laid off by drawing ordinates below *C D* and multiplying one-half the minor axis, or 8" 8, by the complements, and laying off the lengths of the ordinates below *C D*.†

* An "*ordinate*" is a line drawn perpendicular to either axis of the ellipse and terminating in the curve. Thus in Fig. 1 1', 2 2', 3 3', etc., are ordinates.

† From Molesworth's "Pocket-Book of Engineering Formulæ."

PROBLEM 75. *An ellipse being given to find the axes and foci.**

If $A\ C\ B\ D$, fig. 253, is the ellipse, draw any two chords, as $E\ F$ and $G\ H$, parallel to each other. Bisect each of these in I and J, and draw $I\ J$ through the points of division and to intersect the ellipse at K and L. This line divides the ellipse obliquely into two equal parts. Bisect $L\ K$ at O, which will be the center of the ellipse. From O, with any radius, draw a circle cutting the ellipse in $M\ N\ P\ Q$. Join these four points

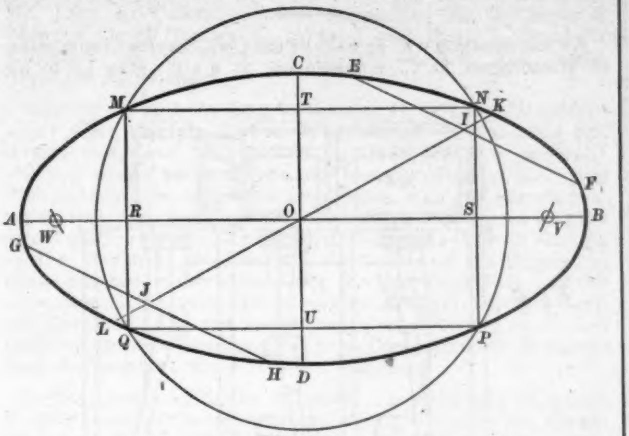


Fig. 253.

by lines, which will form a rectangle within the ellipse. Bisect the sides of this rectangle in R, S, T and U, and draw lines $A\ B$ and $C\ D$ through the points of division. These lines will be the axes of the ellipse.

The foci may be found by describing arcs from C or D as centers, with $O\ B$ as a radius, so as to intersect $A\ B$ at W and V. The points of intersection will then be the foci.

PROBLEM 76. *To draw a line perpendicular to the curve of an ellipse at a given point A, fig. 254.*

Find the axes and foci, as in the last figure. From the foci W and V draw lines through A, and extend them outside of the ellipse. Bisect the angle $B\ A\ C$, and draw a bisecting line $A\ D$, which will be perpendicular to the curve of the ellipse at A. The stones of which an elliptical arch are formed may be laid out by repeating this process.

PROBLEM 77. *To draw a tangent to the curve of an ellipse at a given point E, fig. 254.*

Draw lines $V\ E$ and $W\ E$ from the foci through the point

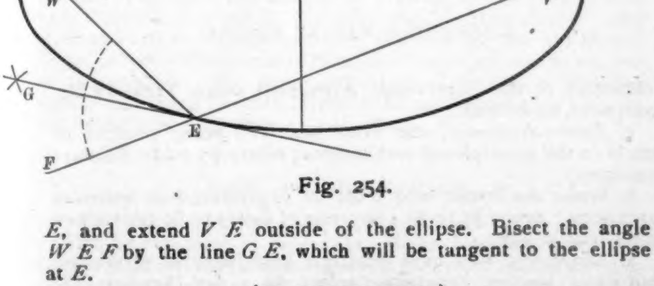


Fig. 254.

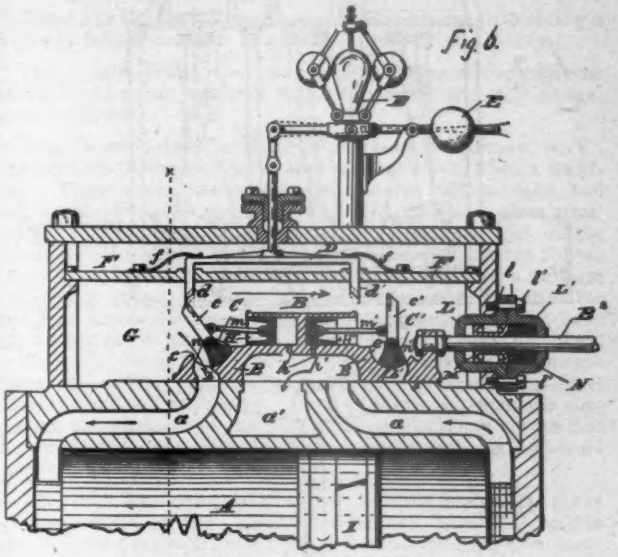
E, and extend $V\ E$ outside of the ellipse. Bisect the angle $W\ E\ F$ by the line $G\ E$, which will be tangent to the ellipse at E.

(TO BE CONTINUED.)

Recent Patents.

KING'S CUT-OFF VALVE.

FIG. 6 represents an ingenious arrangement of cut-off valves intended to be used in connection with a D slide-valve. The ends or "laps" of the slide-valve are made to extend over the steam-ports $a\ a$, and admission-ports $b\ b'$ are provided in the laps. These admission-ports are covered with segmental cut-off valves $C\ C'$, which work in correspondingly shaped seats on top of the slide-valve. The cut-off valves work on journals at $n\ n'$ attached to lugs at each end of the segmental seats, and the valves oscillate on these journals. The cut-off valves also have arms c and c' attached to them which are connected by rods $m\ m'$ to pistons $H\ H'$, which work in a double cylinder B' cast on top of the slide-valve. The cylinders have holes h and



KING'S CUT-OFF VALVE.

h' in their inner ends, which communicate with the exhaust cavity $B\ B$ of the slide-valve, so that any steam behind the pistons can escape. The upper ends of the arms $c\ c'$ have tripping latches which engage with detents $d\ d'$. The vertical position of these is regulated by the governor E in a manner which will be readily understood from the engraving.

The operation of the valves is as follows: If the slide-valve $B\ B$ is moving toward the right side, as indicated by the dart B', the tripping-arm c engages with the detent d, and the movement of the slide-valve thus causes the cut-off valve C to oscillate on its seat and open the admission-port b, and at the same time the rod m draws the piston H outward in its cylinder against the steam pressure in the steam chest. When the slide-valve has moved so far that the tripping-latch is disengaged from the detent d the steam pressure on the piston H forces it into its cylinder, and thus moves the cut-off valve C and quickly closes the admission-port b and cuts off the steam. The action of the valve C', which is represented in the position it occupies when the port b' is closed, is exactly similar to that of C.

Mr. John H. King, of Cincinnati, is the inventor. His patent is numbered 449,123.

MULTIPLE EXPANSION ENGINE.

Figs. 7, 8, 9 and 10 represent improvements in Multiple Expansion Engines for Screw Propulsion, patented by Mr. Hugh Dunsmuir, of Govan, Scotland. He describes his invention as follows:

In adapting triple expansion-engines to operate the propeller-shaft in a single screw-steamer, as represented at figs. 7 and 8, the intermediate and low-pressure cylinders A^2 and A^3 are directly connected each to a crank B on a short shaft C, while the high-pressure cylinder A' is connected to a crank on the propeller-shaft D; or the arrangement may be varied. The two side crank-shafts C and the propeller-shaft D are connected together either by cranks or disks and differently situated crank-pins $D'\ D^2$ and connecting-rods $E\ E'$, which are provided in pairs, as shown, to insure rotation of the several shafts in the same direction.

In adapting triple expansion-engines to operate the propeller-shafts in a twin-screw steamer, as represented at figs. 9 and 10, the high-pressure and low-pressure cylinders A' and A^3 are directly connected each to one of the crank or propeller shafts D, while the intermediate cylinder is connected to a separate crank-shaft C, or the arrangement may be varied; and in order that the power and speed of rotation of the two propeller-shafts

* This and the following problem are taken from "Linear Drawing," by Ellis A. Davidson.

may be equalized and economical working insured, the three crank-shafts are connected together, as shown, by cranks or disks and connecting-rods.

In his specifications he also shows similar plans of applying triple expansion-engines to driving three propeller-shafts, quadruple expansion tandem-engines arranged to drive two propeller-shafts, quadruple expansion-engines for driving four

Fig. 7.

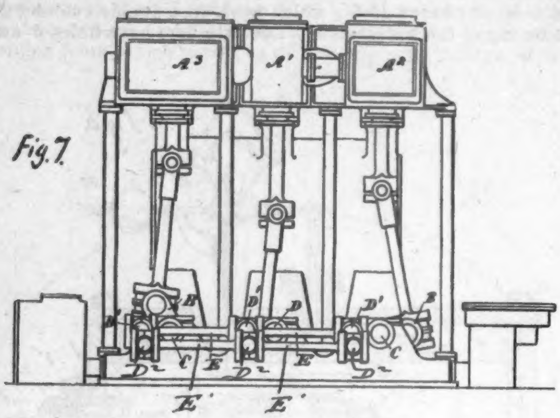
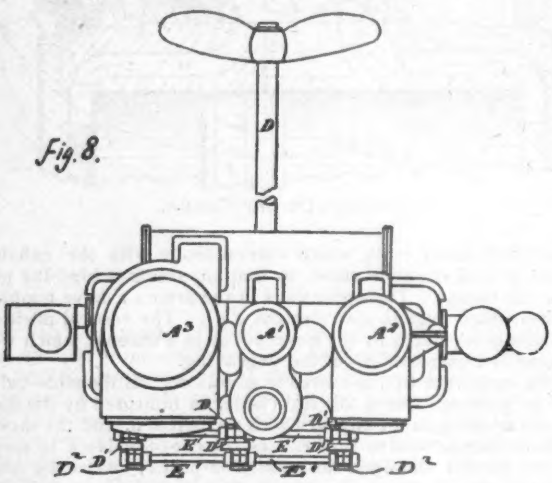


Fig. 8.



DUNSMUIR'S MARINE ENGINE.

propeller-shafts, and two-cylinder compound engines geared to drive twin screw-shafts.

Sound Aluminum Castings.

SOUND castings of aluminum can be obtained in dry sand moulds, preferably lined with plumbago. The metal should be heated to a temperature very little above its melting point, and should be poured quickly. The shrinkage of the above metal is $\frac{17}{64}$ inch to the foot (2.26 per cent. of the length of the mould.)

The above statement, which has been widely published, is not only true as to aluminum, but to all metal castings. Actual sales of plumbago show that barrels of plumbago are now used in shops where pounds were formerly called for. Its use absolutely guarantees to the casting a smooth surface and bright color. Caution is suggested, when purchasing, to obtain exactly the kind wanted for the different work. It can be said of plumbago as the Irishman said of whiskey: "None is bad, but some is better than others." One kind of plumbago is better applied by the shake-bag; and, if the brush is used, another kind will prove better. One preparation of plumbago will "sleek," another will not. Another kind is more useful for light castings, another kind for heavier work.

Good plumbago will stand the heat, and will neither burn nor run before the molten metal.

A wash of plumbago for cores, loam work and dry sand castings is indispensable.

The Dixon Crucible Company, of Jersey City, N. J., have made a patient study of the subject, and being the only miners of plumbago who afterward prepare it for its many uses, they can give advice on the subject not elsewhere obtainable. This is contained in a little book, which can be had from them on application.

Civil Service Examination for Draftsmen.

AN examination will be held by the Civil Service Commission at Washington, D. C., commencing at 9 A.M., May 12, to fill

Fig. 9

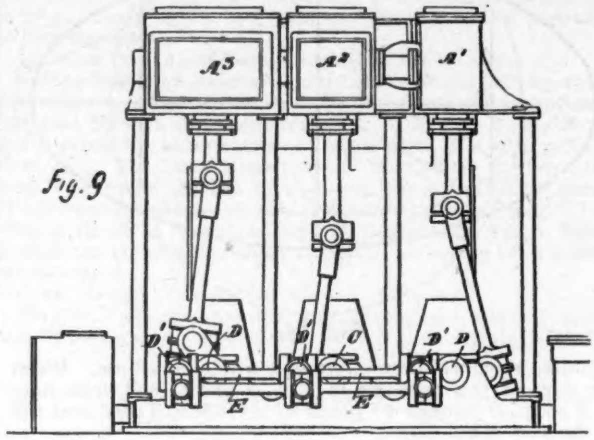
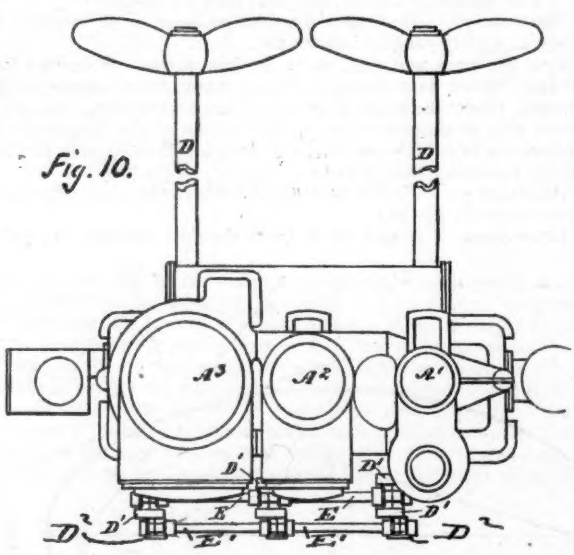


Fig. 10.



DUNSMUIR'S MARINE ENGINE.

vacancies in the Supervising Architect's office, Treasury Department, as follows:

1. *Junior draftsmen*, who must have two years' practice or study in the principles of architecture; salary $3 a day (Sundays excepted).

2. *Senior draftsmen*, who must be experienced as assistant architects; salary $5 to $8 a day, rate of salary to be determined after trial in office.

3. *Draftsmen* who have practical knowledge of steam and hot-water heating apparatus; salary $5 a day (Sundays excepted).

4. *Engineer draftsmen*, skilled in iron-work and building construction; salary $6 to $8 a day, rate of salary to be determined after trial in office.

If there are many applicants from the vicinity of large cities, such as Boston, New York, Pittsburgh or Chicago, arrangements may perhaps be made to hold examinations in such cities if requests are received in time. Blank forms of application may be obtained of the Commission.

Manufactures.

Baltimore Notes.

THE trustees of the Chesapeake & Ohio Canal are making their final arrangements for having the canal in operation by May 1, as required by the order of Court. The trustees are Mr. John K. Cowen, General Counsel of the Baltimore & Ohio; Colonel Bradley S. Johnson and Hugh L. Bond, of Baltimore; H. H. Keedy, of Hagerstown, Md., and Joseph Bryan, of Richmond.

WITHIN the past ten days, ex-Senator H. G. Davis, President of the West Virginia Central & Pittsburgh Railroad, has had several interviews with Mayor Davidson, and it is generally believed among railroad men here that the Western Maryland Railroad will soon be sold to a syndicate, who will operate it in connection with the West Virginia Central. It is said that the recent purchase of the Camden System of roads in West Virginia by the Baltimore & Ohio, and the failure of the Central to secure the bed of the Chesapeake & Ohio Canal, has made it necessary for the latter road to seek an outlet through the Western Maryland; and this is very much strengthened by the fact that the Central is locating a line from Cumberland to Williamsport, the terminus of the Western Maryland.

A WELL-AUTHENTICATED statement has it that the Baltimore & Ohio Company is seriously considering the plans for the extension of the Valley Railroad from Lexington to Roanoke, Va. The distance is about 54 miles, and it is said that the surveys and estimates have been made. If carried out, this will without question be the Baltimore & Ohio route to the South. The Roanoke Southern, which will be built southward from Winston to Monroe, N. C., will be the most valuable connection.

THE South Baltimore Car Works, Curtis Bay, have just closed a contract with the Baltimore & Ohio for the construction of 250 hopper gondola cars of 60,000 lbs. capacity.

IT is said that the Baltimore & Ohio will shortly be in the market for 50 cars of passenger equipment made up of coaches and combined cars.

SOME weeks ago the Ries Electric Traction & Brake Company, of Baltimore, applied their traction-increasing system to Baltimore & Ohio engine 806 for trial. The test was made with an alternating current dynamo, with exciter on same shaft; but the results not being entirely satisfactory, the engine has been ordered into shop, and the alternating current dynamo will be removed and replaced with a direct current dynamo of much greater capacity—perhaps 8,000 ampères—when a further trial will be made. The alternating current dynamo had a capacity of about 4,000 ampères.

THE Scranton Steel Company, of Pennsylvania, by their counsel, have filed a bill in the Circuit Court against the Baltimore & Eastern Shore Railroad Company, of Baltimore, and the Atlantic Trust Company, of New York, trustee, asking for a receiver. This action is brought about by the non-payment of a promissory note for steel rail furnished.

WORK on the Baltimore Belt Railroad tunnel is now progressing rapidly. The tunnel is being driven from six different points; four shafts are located on Howard Street, respectively near German, Lexington, Franklin and Madison streets; one shaft at Park and Preston streets, and through the old Bolton depot property the tunnel is being built by opening the surface of the ground. The open cuts from Hamburg to Camden streets and along Seventh Street in the northern part of the city are being pushed rapidly.

Steel Rails for Australia.

THE Government of New South Wales has made a proposition to steel rail manufacturers, and has invited bids for the supply of 175,000 tons of rails, to be made from material entirely manufactured in the colony from native iron ore and coal or coke. Delivery is to begin in January, 1893, and is to be for three years at the rate of 25,000 tons a year, and for two years at the rate of 50,000 a year. The price is to be regulated by the ruling prices for similar rails in England, with freight and other charges to Sydney added. The bids will be received by the Minister of Public Works in Sydney, and the Agent-General of the Colony in London up to June 24 next.

The attempt of the Colony of New South Wales to establish locomotive works was not successful, and it remains to be seen whether the rail manufacturers will be more ready to take up the offer than the locomotive builders were.

General Notes.

THE Worthington Pump Company has begun work on a branch factory at Elizabeth, N. J. The establishment there will consist of a foundry 143 × 343 ft., with an L 93 × 200 ft., and a pattern and storage shop 80 × 180 ft., and will be a branch of the present works in Brooklyn.

THE Lane Bridge & Iron Company, of Chicago, is building a highway bridge over the Trinity River at Ft. Worth, Tex.

THE Grand Trunk Company is building a rolling mill and steam forge as an addition to its shops at Point St. Charles, near Montreal.

THE Consolidated Car Heating Company, of Albany, N. Y., removed its Chicago office on May 1 to Room 200, Phenix Building. These rooms will always be open to railroad men, and will be supplied with models of its car heating and other apparatus. This Company submitted an elaborate brief to the meeting recently held of the Superintendents of Motive Power of the Vanderbilt Lines, showing the requirements for a uniform coupler for steam heating. These requirements are that the couplers should be steam-tight; uncouple automatically; have an unobstructed passage for steam; have no movable parts, springs, etc.; hang below the air coupling; have as few projections as possible; be interchangeable; easily coupled; simple, compact and not expensive. Each of these statements is supported by reasons, and the Consolidated Company claims that the only coupler answering to all those requirements is the Sewall coupler.

THE Port Richmond Iron Works, in Philadelphia, for many years operated by I. P. Morris & Company, have been sold to the William Cramp & Sons Ship & Engine Building Company. The works are extensive, and have done a large business in engines and other machinery, and will be a valuable addition to the Cramp yards.

A TRIAL of the Servé ribbed boiler tubes was made in the works of Samuel L. Moore & Sons Company, at Elizabeth, N. J. A boiler was first run with plain tubes two days with natural draft and two days with forced draft. The plain tubes were then removed and ribbed tubes substituted, and the boiler was run with the new tubes for two days with natural draft and two days with forced draft. The trial was made under charge of Mr. H. B. Roelker and was very carefully conducted, but at the time of going to press we have not received the full report.

A PLANT is to be erected in Scranton, Pa., for making fuel from culm and coal waste by the Phelps process, which is substantially a water-gas process, and it is expected that its use will be introduced in a number of places throughout the coal region where culm is plentiful, and easily obtained.

THE "Aerator" car, which was recently fitted up by the Pennsylvania Railroad on the plan of Mr. R. M. Pancoast, of Camden, N. J., is now being tried carrying fruit from Florida to Northern markets. In this car the use of ice is not necessary. A similar car fitted up by the Baltimore & Ohio Railroad is now being used carrying oranges from Southern California to Philadelphia. On its first trip the fruit was brought through in very good condition.

THE Scarritt Furniture Company, of St. Louis, has taken a contract to supply the Scarritt-Forney high-back seat for several passenger cars now under construction by the Barney & Smith Company, in Dayton, O., for the Pittsburgh, Shenango & Lake Erie Railroad. These are very handsome cars. Scarritt-Forney seats are also being furnished for two first-class cars now being built for the East Louisiana Railroad.

THE Baldwin Locomotive Works, Philadelphia, have taken a contract to build 48 engines for the Northern Pacific Railroad. Of these engines, 40 will be mogul freight engines of the standard pattern of the road, and the other eight will be consolidation engines with 22 × 28 in. cylinders for the mountain divisions.

THE new yards of the Chicago Ship Building Company, at South Chicago, have a front of 1,400 ft. on the Calumet River, and cover 21 acres of land. There are three building slips, and between two of these is a powerful steam derrick which is used for delivering material to the vessels under construction. The main building is 570 × 75 ft., and there are a number of smaller shops. The first steamship built was recently launched, as we

have already noted, and another vessel of the same size is nearly completed.

THE Rogers Locomotive Works, Paterson, N. J., have recently completed a large order for mogul engines with 19 × 24-in. cylinders for the Chicago, Burlington & Quincy. They are now building for the same road three decapod engines, with 22 × 28-in. cylinders; these engines have five wheels connected, and a two-wheel truck. They are also filling an order for mogul passenger engines, with 19 × 24-in. cylinders and 60-in. drivers for the Norfolk & Western Railroad.

THE opalite surfacer, made by the Charles C. Phillips Company, Philadelphia, for priming and surfacing car and locomotive work, has been adopted on a number of railroads with very satisfactory results.

THE present sent by the Mason Regulator Company, of Boston, to its friends at Easter was a "fresh egg" packed neatly in a small box. The shell was apparently perfect, but on cracking it the yolk was found to consist of yellow tissue paper, on which was printed a brief reference to the Mason Company's reducing valves, air-brake regulators and damper regulators. The whole device was very neat.

THE life of ordinary roof paints is from two to five years. It is claimed that Dixon's graphite paint, however, will last from 10 to 15 years on outside work. This paint is especially useful in localities where a surface is likely to be corroded by acids and alkalies. An example of its use on a large scale is on the new elevated line of the Pennsylvania Railroad in Jersey City.

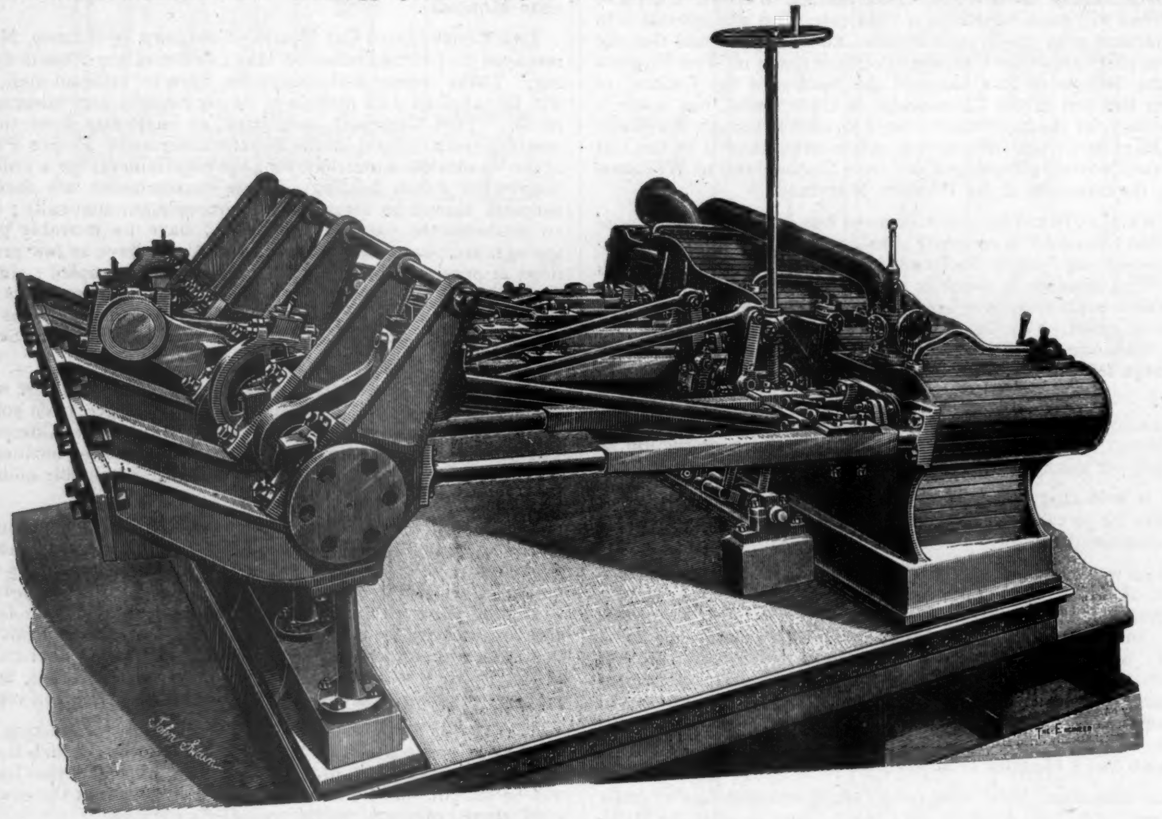
THE Pennsylvania Railroad shops in West Philadelphia are putting in a Thomson-Houston electric welding machine, to be used in boiler work. The car shops last month turned out a total of 92 cars. The paint shop at this place is provided with an elaborate system of ventilation, which has worked very well, not only in keeping the air in the shop pure, but also in assisting the drying of paint and varnish on cars.

THE Toledo Machine & Tool Company, Toledo, O., has bought the entire plant of the Smith & Haldeman Elevator Company, including all patterns, tools, etc., and is now located in the shops on Superior and Oak streets, with a much enlarged capacity for work. In the new shops the company will make punching presses and other sheet-metal tools in addition to the small work heretofore done. The concern was started by G. F. Danielson three years ago, and has been remarkably successful.

THE Harlan & Hollingsworth Company, at Wilmington, Del., is building two iron steamers for the line between Norfolk and Washington. The first of these, the *Washington*, was recently launched. She is 260 ft. long over all; 37 ft. beam moulded; 46 ft. wide over guards; 16½ ft. deep and draws 10 ft. of water. The engine is of the direct-acting inverted triple-expansion type, with cylinders 22 in., 36 in. and 55 in. in diameter and 28 in. stroke. The passenger accommodations are very handsomely fitted up, and the boat has a large capacity for freight. On the trial trip, with 118 revolutions per minute, the ship made 16⅞ knots an hour.

DURING March the Schenectady Locomotive Works turned out 35 engines, including sixteen 19 × 24-in. 10-wheel freight and eight 18 × 24-in. 10-wheel passenger, for the Chicago & Northwestern; five 19 × 24-in. 10-wheel freight for the Chicago, St. Paul, Minneapolis & Omaha; one 18 × 24-in. mogul for the Bennington & Rutland; one 18 × 24-in. 10-wheel (completing an order for 25) for the Atchison, Topeka & Santa Fé; one 17 × 24-in. 6-wheel switching engine for the Grand Central Station, New York; one 18 × 24 in. 6-wheel switching engine for the Fitchburg; two 18 × 24-in. 6-wheel switching locomotives for the Northern Pacific Terminal Company.

THE new bridge over the Arkansas River at Ft. Smith, Ark., was completed March 30, when the draw-span was swung into position. This bridge was built by the Union Bridge Company, and is 2,370 ft. in length over all.



TRIPLE-EXPANSION ENGINE FOR SIDE-WHEEL RIVER STEAMER.

A Light Side-Wheel Engine.

THE accompanying illustration, from the London *Engineer*, shows an engine built by the Southampton Naval Works for a light side-wheel steamer, intended to run on the Nile. The engine is of the triple-expansion type, with cranks set at an angle of 120°, the cylinders being 12½ in., 20 in. and 30 in. in diameter, by 36 in. stroke. The high-pressure and intermediate cylinders have piston valves, the low-pressure a plain slide valve, each worked by a link motion. The air, feed and bilge pumps are all in one casting; they are worked by levers and links from the low-pressure cross-head. The condenser is entirely separate, and is cylindrical in form, of copper.

The general design of the framing and the arrangement of the engines on the flat bottom of the boat are well shown in the engraving. The wheels are of the feathering type, and are 6 ft. 9 in. in diameter.

Steam is supplied by two boilers of the locomotive type, 42 in. in diameter and 15 ft. long, working at a pressure of 160 lbs. They will work under forced draught, on the closed ash-pan principle.
There will be a small engine for running the dynamo for the electric lights. This engine will take steam from a smaller boiler, also of the locomotive type.

OBITUARY.

CAPTAIN THOMAS H. LAPSLEY, who died at Braddock, Pa., April 10, was well known from his long experience in rolling-mill work. He was 72 years old, and had been Superintendent of the Edgar Thompson mill ever since these works were started. He had suggested and made many improvements in his department.

J. EDWARD LARKIN, who died at Havre de Grace, Md., April 11, aged 60 years, was born in Yarmouth, Mass., and entered the service of the Philadelphia, Wilmington & Baltimore Railroad under the late President Felton, and had been connected with the road ever since. For a number of years he had charge of the bridges on the road, and had a part in designing a number of the present structures. At the time of his death he was in charge of the bridge over the Susquehanna between Havre de Grace and Perryville.

PERSONALS.

R. W. BAXTER has been appointed Superintendent of the Ohio Division of the Baltimore & Ohio Railroad.

J. M. JOHNSON, for some time past Engineer of the Louisville Bridge & Iron Company, has been appointed President also.

ROBERT QUAYLE, recently on the Chicago & Northwestern, is now Master Mechanic of the Milwaukee, Lake Shore & Western Railroad.

P. C. SNEED is now Superintendent of the Chicago Division of the Baltimore & Ohio Railroad, succeeding F. H. BRITTON, who has resigned.

ALFRED H. RAYNAL, lately with the Richmond Locomotive Works, has been appointed Superintendent of the works of the Samuel L. Moore & Sons Company at Elizabeth, N. J.

RICHARD RANDOLPH, late Consulting Engineer, has been appointed Chief Engineer of the Baltimore Belt Railroad in place of SAMUEL REA, who has resigned on account of ill health.

T. F. WETHERBEE has been appointed General Agent of the Westinghouse Machine Company at Durango, Mexico. He has been for some time engaged in mining operations in that vicinity.

C. C. ELWELL is now Engineer of Maintenance of Way of the Philadelphia Division, Baltimore & Ohio Railroad, succeeding W. A. PRATT, who has been transferred to the Pittsburgh Division.

JAMES H. WINDRIM, for some time past Supervising Architect of the Treasury Department, has resigned that office, and has accepted the position of Director of Public Works of the City of Philadelphia.

W. M. HUGHES, Assistant General Manager of the Keystone Bridge Company, has been appointed Engineer of Construction for the buildings for the Columbian Exposition. He will have his office in the Rookery Building, Chicago.

WILLOUGHBY J. EDBROOKE, of Chicago, has been appointed Supervising Architect of the Treasury Department. He is an architect of considerable experience, and was at one time Commissioner of the Chicago Building Department.

E. DICKINSON has resigned his position as General Superintendent of the Trans-Ohio lines of the Baltimore & Ohio Railroad. He returns, as Assistant General Manager, to the Union Pacific, from which road he went to the Baltimore & Ohio.

W. M. MITCHELL, recently appointed Railroad Commissioner of Kansas, has been a railroad man for 20 years, serving as brakeman, fireman, station agent and conductor. He was recently a conductor on the Atchison, Topeka & Santa Fé.

HENRY GOLDMARK has been appointed Consulting Bridge Engineer of the Kansas City, Fort Scott & Memphis Railroad. He has his office in Kansas City, Mo. Mr. Goldmark had charge of the building of the bridge over the Arkansas River at Little Rock.

CAPTAIN GEORGE C. DICKINSON, C.E., late Division Engineer on the Hudson Suspension Bridge & New England Railroad, has been appointed Chief Engineer of the Broadway & West Virginia Railroad; his office is at Broadway, Rockingham County, Virginia.

NAVAL CONSTRUCTOR R. W. STEELE, U. S. N., has been ordered from Philadelphia to the Mare Island Navy Yard, where he will relieve Naval Constructor Fernald, who goes to the New York Yard. Mr. Steele has been on duty at the Cramp yards for several years.

JOHN HICKEY has been appointed Superintendent of Motive Power of the Northern Pacific Railroad. Mr. Hickey has been for several years Master Mechanic of the Milwaukee, Lake Shore & Western, where he has made a reputation as a master mechanic of ability and judgment.

MAJOR N. S. HILL, formerly for many years Purchasing Agent of the Baltimore & Ohio Railroad, is now in charge of the construction of an extension of the West Virginia Central & Pittsburgh Railroad, from Elkins, W. Va., to Bealington. C. H. LATROBE is Chief Engineer of the road.

OSCAR SAABYE, C.E., has resigned his position as Assistant Engineer of Maintenance of Way of the Roanoke Division, Norfolk & Western Railroad, and has entered into partnership with CLARENCE COLEMAN, C.E. They will conduct a general civil and mechanical engineering business, and have established their office at Room 12, Moorman Building, Roanoke, Va.

NAVAL CONSTRUCTOR WILLIAM L. MINTONYE, U. S. N., has been detached from the New York Navy Yard, and ordered to duty at the Boston Navy Yard. He is relieved at New York by NAVAL CONSTRUCTOR FRANK S. FERNALD, who has been for some time past at the Mare Island Navy Yard. Mr. Mintonye has been on duty at the New York Yard for several years, and has had immediate charge of the work on the *Maine* and other new ships.

PROCEEDINGS OF SOCIETIES.

General Time Convention.—The spring meeting of the Time Convention was held in New York, April 8, with a fair attendance, and the usual routine business was transacted.
The Committee on Car Service made a report dealing chiefly with the Demurrage Question, and giving some account of the experience reported by the Car Service Association.
The Committee on Train Rules made a report recommending some slight changes in the present standard rules.
The Committee on Safety Appliances made a report of progress, giving statistics obtained from various roads, principally on steam heating, but making no recommendations.
The new rules reported at the last session were presented and adopted; and it was resolved to change the name of the organization to the American Railway Association. It was decided to hold the next meeting October 14.
The following officers were elected for the ensuing year: President, H. S. Haines; Vice-Presidents, H. F. Royce, Lucius Tuttle; Secretary, W. F. Allen; Executive Committee, G. W. Stevens and C. W. Bradley.
President Haines then made his annual address, which was principally devoted to the training and discipline of railroad men.

American Water-Works Association.—The annual meeting began in Philadelphia, February 14, with a large attendance. At the opening session the President made his annual address, calling attention to the importance of the work.
At the business session the report of the Committee on Cast-iron Water Pipes was read, describing the defects commonly found in such pipes, and recommending a uniform system of tests. Other papers read were on the Philadelphia Water-Works, by E. Geyelin; Steel Water Pipe, by J. R. Dunkin, and the Columbus Water-Works, by A. H. McAlpine, and Animal and Vegetable Matter Effecting Water Supply, by Professor Leeds.
In the evening a reception to the members was given at the rooms of the Manufacturers' Club.
The papers read on April 15 included a number of much interest, among which were Water-Works, by Charles Bush; Water Pressure Gauges, by C. A. Hague; Hydraulic Elevators,

by B. F. Jones; Flow of Water in Pipes, by Joseph B. Rider; Water Rates, by H. G. Holden, and others. In the afternoon the members were taken through Fairmount Park and to the Philadelphia Water-Works.

On April 16 a considerable part of the time was devoted to the discussion of questions submitted by members, and several papers were read, including the Purification of Water by Metallic Iron, by Dr. Henry Leffman; Private and Public Works, by E. W. Moss; and Water Motors, by S. E. Babcock.

The meeting on April 17 was devoted to the usual routine business. Mr. J. M. Diven was elected President, and J. H. Decker Secretary. It was resolved to hold the next convention in New York.

Master Mechanics' Association.—The Committee on the Purification of Feed-Water requests information from all members who have tried various devices, chemical and mechanical, for this purpose. The Chairman of this Committee is W. T. Small, St. Paul, Minn.

The Committee on Examination of Locomotive Engineers and Firemen requests information as to the methods adopted on different roads, whether examination is required, and what plans are employed? The Chairman is Mr. W. H. Thomas, Knoxville, Tenn.

The Secretary has issued a reminder to members as to the importance of their answering circulars as fully and as promptly as possible, in order that the committees may be able to make full and proper reports.

Master Car & Locomotive Painters' Association.—The Advisory Committee has prepared the following list of subjects and queries for the annual convention in Washington, September 8, and they are issued in a circular by Secretary R. McKeon:

SUBJECTS.

1. Is there a chemically pure soap that can be safely used for the purpose of cleaning the outside varnished surface of the Railroad Passenger Coach while in service? stating soap, results and method of cleaning.
2. As a question of economy and durability, should Rough stuff be discarded on the outside surface of a Railroad Passenger Coach? If so, what materials and methods of application will best answer the requirements of this class of work, durability being the main consideration?
3. According to the practical experience and ideas of Railroad Car and Locomotive Painters, can a new locomotive receive a durable finish in 10 days, stating method and materials used?
4. As an Associated Body, can we exert an influence on purchasing power that would remedy where necessary the quality of materials furnished? An item of great importance when viewed from the standpoint that the best procurable is the most economical, as demonstrated through practical experience in the Railroad Paint Shop.
5. How should the New Wood Head-Lining material of a passenger coach be treated to prevent the finished surface from becoming destroyed from decay of filler, grain raising, etc., due to the interior heat and moisture of a passenger car?
6. Are Railroad Companies benefited through the Association of Master Car & Locomotive Painters? Essay.
7. Reports of committee of 12 appointed on geographical interchange of test panels painted and exposed for a period of 10 months in the extreme different climatic sections of the country.

QUERIES.

1. Would it be advisable to form a Bureau of Information in connection with our Association?
2. Do you use part or all shellac on the hard wood inside finish of your passenger cars?
3. How do you prepare your stack blacking for Locomotives while in service?
4. What materials do you use and how long do you take to paint your Freight Cars?
5. As an item of shop economy, in what manner can you keep your paint stock and brushes in the most serviceable state?
6. What is the best formula for preparing floor paint for passenger cars?
7. What are your views concerning the piece-work system for the Railroad Paint Shop?

American Society of Civil Engineers.—At the regular meeting, April 1, Mr. J. Foster Crowell presented a paper on the Ravine du Sud, Haiti, and Mr. W. E. Worthen presented a paper on the Concrete Sewer at Mt. Vernon.

A motion was made and carried requesting the Board of Directors to keep the rooms of the Society open every evening except Sunday.

The tellers announced the following elections: *Fellow*, Edwin D. Adams, New York.

Members: Job Abbott, New York; Francis C. Gamble, Victoria, B. C.; Charles A. Wilson, Toledo, O.

Associate Members: William F. Jordan, Rochester, N. Y.; Levis P. Pennypacker, Clement I. Walker, New York.

Associates: S. G. Comfort, Chester, Pa.; J. R. Dunn, W. C. Oastler, New York.

Juniors: W. E. Belknap, P. Smith, Jersey City, N. J.; E. J. Chibas, Pittsburgh, Pa.; L. B. Jenckes, South Manchester, Conn.; A. H. Wood, National City, Cal.; J. C. L. Rogge, New York.

AT the regular meeting, April 15, the Secretary read a paper by Mr. A. M. Hawks on the Automatic Refrigerator System at Denver, describing the plant there, which has been in operation for two years successfully, and which is on the ammonia system.

Mr. C. P. Bassett read a paper on the Sewage Disposal at East Orange, describing the new works in that place.

Engineers' Club of Philadelphia.—At the regular meeting, March 17, the tellers reported that the new Constitution and by-laws had been adopted.

The Secretary presented notes on the Mississippi River Discharge, by J. J. Hoopes; notes on Street Cleaning in Washington, by C. B. Hunt, and a description of the Reinforcement of Foundation in a Draw-bridge Pier, by Howard Constable. The subject of Street Cleaning on Asphalt and other smooth pavements brought out some discussion, and the Committee on Information was requested to report to the Club on the practice in this matter in various important States.

Mr. Rudolph Hering continued his paper on the Corrosion of Iron and Steel, and referred to galvanic action as a very common cause, giving the results of experiments made in this country and in England, which established the fact that corrosion was much more rapid when galvanic action took place than otherwise.

AT the regular meeting, March 21, the Secretary announced that the Directors had elected David Townsend Vice-President in place of S. M. Prevost, resigned, and S. H. Chauvenet an additional Vice-President, in accordance with the new Constitution. Mr. T. Carpenter Smith was elected Treasurer.

The appointment of the following standing committees was announced:

Finance: P. G. Salom, F. H. Lewis and S. H. Chauvenet.

Membership: David Townsend, P. G. Salom and S. H. Chauvenet.

Publication: Rudolph Hering, John C. Trautwine, Jr., and Professor H. W. Spangler.

Library: George S. Webster, Rudolph Hering and P. G. Salom.

Information and Entertainment: H. W. Spangler, George S. Webster and F. H. Lewis.

House: F. H. Lewis, John C. Trautwine, Jr., and David Townsend.

The Secretary presented for Mr. Harry B. Hirsh an illustrated description of an Iron Sewer Template which had been used in the construction of a cement sewer.

Mr. Strickland L. Kneass presented notes on the Discharge of Steam into the atmosphere through tubes of different shapes, with pressures from 30 to 120 lbs. per square inch.

The results showed that for all pressures above 25 lbs. the velocity of discharge at any given section of a correctly proportioned tube was practically constant; and that under the same conditions the flow of weight was almost directly proportional to the initial pressure.

A simple formula, comparing very closely with observed results, was given for determining the weight of steam discharged per second from an orifice, in terms of the initial density of the fluid.

There was some discussion of this paper.

AT the regular meeting, April 4, Professor H. W. Spangler called the attention of the club to the fact that while steam passes through an orifice at approximately a constant velocity, if an opening is made below the water level of a boiler the quantity of water passing out under any pressure in unit time is prac-

tically constant. This is due, of course, to the fact that as the water passes from the boiler into a passage in which there is less than boiler pressure, a portion of the water is converted into steam, and while the velocity in this case is different for different pressures, the total quantity of water is practically the same at all pressures. In other words, as long as the pressure in the boiler is practically constant, the time of emptying the boiler is always the same through the same orifice. This was further discussed.

Mr. Thomas G. Janvier read a paper on the Engineering Features of the Road Question, which was followed by some discussion.

A paper was presented for Mr. C. R. Claghorn on the Alabama Coal Fields. This described the three principal fields with their characteristics, and the quality of coal taken from them.

Engineers' Society of Western Pennsylvania.—At the regular meeting in Pittsburgh, February 17, Charles A. Camp, E. E. Means, Emil Hallgren, W. H. Kemler, J. Branne, J. M. Deforth, E. K. Scott, James B. Hardie and George Jewett Hicks, were elected members of the Society.

There was a long and very interesting discussion on Mr. C. F. Scott's paper on Electrical Mining Machines, in which nearly all the members present took part, and many interesting facts were brought forward to show the advantages of the use of electricity in operating machinery underground.

Engineers' Club of Cincinnati.—At the regular meeting, March 19, A. A. Daniels, A. O. Elsner, F. W. Wrampelmeier, William E. Dowson, William H. Rabbe and Henry Dreses were elected to membership.

The question, Will a cut of 5,000 cubic yards make a fill of 5,000 cubic yards after a haul of from 500 to 1,000 ft.? was discussed at considerable length.

The paper for the evening, by W. H. D. Totten, comprised a description of the plants of the Edgar Thomson and the Homestead Steel Works of the Carnegie Association, of Pittsburgh.

Civil Engineers' Club of Cleveland.—The eleventh annual banquet of this Club was held at the Stillman House, in Cleveland, March 17, about 200 guests being present. The banquet was much enjoyed, and still more pleasure was derived from the speaking after dinner. The different toasts and the gentlemen who responded to them were: "The Starry Heavens," Professor C. S. Howe; "The Earth," Dr. Carl von Kline; "Electricity," Professor Cady Staley: "The Air," Mr. C. P. Leland; "Iron and Steel," Mr. S. T. Wellman; "Aluminium and Brass," Mr. W. R. Warner; "Stone and Brick," Mr. John Eisenmann; "Wood," Mr. James Ritchie. The regular speaking was followed by a number of volunteer toasts.

At the regular meeting, April 14, Frank R. Lander was elected a member. The Programme Committee reported arrangements for meetings for the ensuing year.

Professor Charles H. Benjamin read a paper on the Education of the Mechanical Engineer, advocating practical as well as theoretical training. This was generally discussed by members present.

Civil Engineers' Society of St. Paul.—The regular meeting, in St. Paul, April 6, was the third joint meeting of the St. Paul and Minneapolis Societies. Mr. F. W. Cappelen read a paper on the Minneapolis Suspension Bridge. The first bridge across the Mississippi River was a suspension bridge of 560 ft. span, built in 1854. This was replaced by the structure described in the paper in 1876, and it in turn was taken down to make room for the present steel-arch bridge, the wood-work being completely wrecked by dry rot. The cables were removed wire by wire, each one having been pulled from its place and coiled on a drum by steam power at an average cost of 20 cents per wire or a trifle more than 0.4 per pound. The total length of wire thus wound was 1,421 miles. The cost of demolishing the bridge was $11,000. Mr. Cappelen demonstrated that the loaded cables assumed the form of a parabola rather than the catenary. The anchorage irons, although bedded in cement, were found to be deeply corroded.

Discussion of the paper brought out the fact that wooden trusses in the Northwest are commonly built of green lumber, which should not be painted, except at the joints, until thoroughly seasoned, and that oak keys for pine timbers may be wrapped in tar paper to advantage.

Montana Society of Civil Engineers.—A special meeting was held in Helena, Mont., February 14, to discuss the question of memorializing the Legislature in favor of the creation of the office of State Engineer. The question was discussed and a letter from the President was read, and it was finally resolved to appoint Mr. W. A. Haven to report to the next meeting the proper action to be taken.

An adjourned meeting was held in Helena February 28. The Committee appointed at the previous meeting reported that it was not expedient to petition the Legislature at the present session, as there does not appear to be any pressing need for such an office, although without doubt the time will come within a few years. It was recommended that a Committee should be appointed by the Society to collect full data as to the office of State Engineer in such States as it exists west of the Mississippi. The report was approved, and the resolution for the appointment of a special committee was passed.

The Secretary presented a report showing that the total receipts for last year were $411 and the expenditures $417.

It was resolved that standing committees on Topics, Library and National Public Works should be appointed for the ensuing year, and other routine business was disposed of.

New England Railroad Club.—At the meeting in Boston, April 8, Mr. Angus Sinclair presented a paper on Inspection of Air-Brakes of Freight Cars, which was generally discussed by members present.

A Committee of three was appointed to report changes in the rules for interchange of freight cars, to be discussed at the May meeting of the Club.

Central Railroad Club.—At the meeting, in Buffalo, April 8, the report of the Committee on Inspection of Repair and Air Brakes was presented. It recommended additions to the rules of interchange covering repairs of brake apparatus. This report was discussed, and a number of other amendments to the rules of interchange were suggested and discussed.

Western Railway Club.—At the regular meeting in Chicago, April 21, the first subject was the discussion of the paper on the Improvements in Locomotive Boiler Construction, read by Mr. Hickey at the March meeting.

The second subject was the discussion of the amendments in the Interchange Rules, the object being to prepare members for the discussion at the Car Builders' Convention.

NOTES AND NEWS.

Amended Rules for Boiler Construction.—The report of the regular meeting of the Board of Supervising Inspectors of steam vessels, which has just been officially promulgated by the Secretary of the Treasury, introduces some important amendments to existing rules, adapting them to improved qualities of boiler steel plate and methods of application.

In regard to lap-welded flues it is required, in addition to the old rules, that flues 7 in. and not over 16 in. in diameter shall be made in lengths of not over 3 ft., and fitted one into the other and substantially riveted; or in lieu thereof shall be corrugated to a depth of not less than $\frac{3}{4}$ in. outwardly, and at a distance of not over 3 ft. between such corrugations: *Provided* such corrugations are made without in any manner reducing the thickness of the material in the flue at the points of corrugation to less than the least thickness of the material in the body of the flue, or that such flues are made in sections of not over 3 ft. in length, and flanged to a width of not less than 2 in., and riveted substantially together with a wrought-iron ring, having a thickness of material of not less than the thickness of material in the flues, and a width of not less than 2 in., riveted between such flanges. The thickness of the lap-welded flues shall not be less than the product of the constant 2.20 multiplied by the diameter of the flues in inches, which will express the thickness in hundredths of an inch.

For cylindrical boiler flues over 16 in. and less than 40 in. in diameter the following formulas shall be used in determining the pressure allowable: Cylindrical boiler flues over 16 in. and not over 40 in. in diameter shall be made in lengths of not over 3 ft., fitted one into the other, and substantially riveted, or flanged to a depth of not less than 2 in. and riveted together with a good and substantial wrought-iron ring between each joint, and no such ring shall have a thickness of less than $\frac{1}{2}$ in., nor a width of less than 2 in., and the maximum steam pressure per square inch allowable shall be determined by the formulas given.

The amended rules are very complete and give full directions as to Government requirements for coil and pipe boilers, constructed in all parts of wrought iron and steel plates.

Repairing Wet Arches.—In a recent number of the *Centralblatt der Bauverwaltung* was an account of a very satisfactory method of repairing damp tunnel arches, employed on the Trier Division of the Prussian State Railways by Herr Blum, the author of the article from which the following abstract is taken: The plan of the work was very simple, being merely

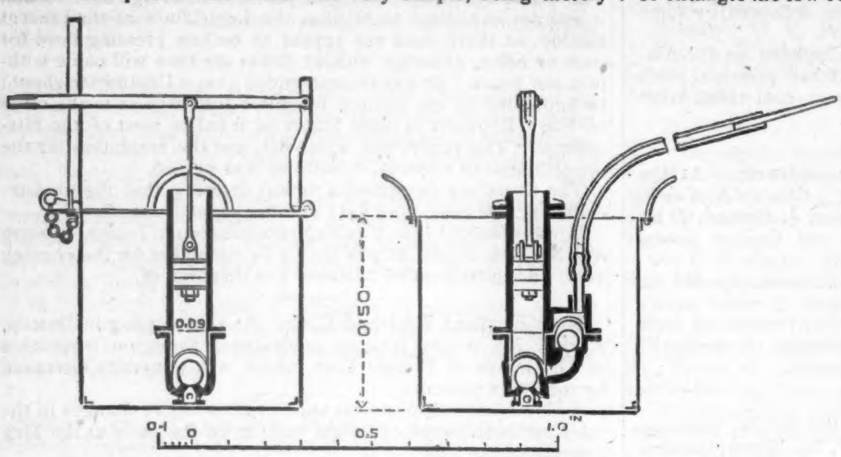


FIG. 1. FIG. 2

the injection of cement through cracks and holes in the masonry, which became practically a monolithic mass as soon as the cement had hardened. This method of drying a tunnel was never employed until a careful examination of the surface of the ground had been made, and it was found impossible to remedy the faults by draining.

Where drainage will not suffice, the tunnel walls are carefully examined, and all joints not tight are scraped out to a depth of 2 in. and caulked with about 0.8 in. of oakum, and the remaining void filled with cement in the usual manner.

At the same time that this work is being done, workmen are boring the $1\frac{1}{2}$ in. holes through the masonry into which the current is to be injected. This cement is intended to fill not only the outer parts of the joints, but also to cover the whole exterior of the masonry if there are air spaces about it. As the work of boring these holes is expensive, care should be taken that they are driven at the most advantageous points. Experience has shown that a distance of 3 ft. between the holes is as great as is consistent with good results; in very wet places this should be reduced by a third. Whether the holes are best driven through the stone or in the joints depends entirely upon the nature of the arch, especially the character of the stone, and must be determined independently for each case. Where soft stone is employed, it is generally better to drill through the voussoirs, especially if their faces were not dressed flat, since the holes through the joints will be very rough and uneven in such cases, and the additional labor in injecting the cement will more than counterbalance the slight saving in boring.

The semi-fluid cement that is forced into the crevices is composed of five parts of cement and four of water. The injecting pumps are shown in figs. 1 and 2. The pump barrels are of brass, and the nozzle at the end of the rubber pipe is copper. The price of the apparatus, with 10 ft. of 2 in. rubber pipe, was about $42. With a wooden tub the cost would be considerably less. The cement must be carefully stirred, and it is necessary to clean the pumps thoroughly at least once every day. The cement is injected at the crown first by thrusting the copper nozzle through the oakum caulking, and pumping until the material shows in a neighboring hole or joint. Whenever the cement appears in the joints the openings are carefully plugged, the pumps stopped, and moved to the next hole. The work is usually done by means of scaffolding mounted on wheels, running on the track in the tunnel. As soon as the crown has been made impervious the sides of the tunnel become damp. This is best remedied by breaking small openings through the tunnel sides, and making, if possible, small drains, filled with stone, up toward the crown on the outside of the masonry. The cost of the work varies greatly with the condition of the tunnel, varying in several cases cited from $1.56 to $3 13 per square yard of surface.

Towing on Canals.—At a recent meeting of the German Railroad Association in Berlin, M. Wiebe presented some notes on the trials made on the Oder-Spree Canal in the mechanical traction of boats. The two divisions of the canal having a total length of about $3\frac{1}{2}$ miles, the trial was made with a cable kept in continuous movement, to which the tow-ropes from the boats could be attached. This cable was driven by stationary engines and carried on pulleys fixed on posts, supports of different forms being tried. In one respect the results were satisfactory, as boats could be easily attached to the cable and detached from it. The most serious difficulty was the tendency of the cable in movement to turn around on its axis and so entangle the tow-ropes. No arrangement tried could prevent this, and it seemed sufficiently difficult to prevent further development of this system.

On the same canal towing by a locomotive running on a track on the tow-path was also tried. As it was considered that the tendency would be to bring the engine from the track, a car was provided to which the tow-rope could be fastened. This car was heavily loaded, so as to bring the center of gravity as near the ground as possible. The track upon which it ran was a light one, similar to those used in mines. The results in this respect were satisfactory; on occasion a speed of about eight miles an hour was reached, but from three to four miles is sufficient for ordinary towing. For large boats loaded with coal it was found that the strain upon the tow-rope was about 1,700 lbs. in starting, but when the boat was once in motion the work was much less. In convex curves it increased, but it diminished on concave curves. A grade in the track did not make any difference in the work necessary to move the boat.

Ancient Ship Railroads.—If a search were made among the papyri at the British Museum, evidence would be found that the Egyptians were in the habit of transporting vessels overland across the isthmus of Suez, and it is, indeed, more than probable that they did so. Tradition records that 23 centuries ago a true ship railroad, with polished granite blocks as rails, existed, and was worked across the Isthmus of Corinth, where the construction of a ship canal has just now only been partly effected and subsequently abandoned for financial considerations. In 1718 the well-known Count Emanuel Swedenborg constructed a road and "machines" for carrying laden vessels from Stromstadt to Iddefjord in Sweden, a distance of 14 miles across a rough country, and the successful use of this work by Charles XII., during the siege of Frederikshall, led to Swedenborg being regarded not only as a national benefactor, but as a mechanician of no mean ability for at least a century after his death.

The vessels transported in all the above cases were, no doubt, small in size and weight compared with modern vessels. Necessarily, also, any vessel carried in our own times on an ordinary railroad must be comparatively small, or it would not be able to pass under bridges and through tunnels. Within the latter limits, however, no practical difficulty whatever has been found in sending small vessels by rail at the usual speed of good trains. The Dutch have shifted torpedo boats from one part of the coast to another on railroad trolleys, and Mr. Donaldson, the torpedo-boat builder, some time since forwarded his steam yacht from the Thames to the west coast of Scotland by rail, having, of course, removed masts, funnel, and all deck hamper to enable her to squeeze through tunnels.—*Fortnightly Review, London.*

The Road Question.—In a paper recently read before the Engineers' Club of Philadelphia by Mr. Thomas G. Janvier, on the Engineering Features of the Road Question, the author said that this branch of the road question should be divided into three parts: 1. Location; 2. Preparing the road bed; 3. Laying the pavement.

Location.—The item of expense should be well considered. In this connection, grading, land damages, etc., should not be overlooked. The line should be as direct as possible, remembering that a slight deflection to the right or left or an easy curve might save considerable expense in the matter of excavation, embankment or bridging. The grades should be made as easy as possible, not exceeding 7 ft. per 100, or less than 8 in. per 100 ft. Excessive excavations and embankments should be avoided.

The full width should not be less than 40 nor more than 60 ft. but the paved portion need only be from 18 to 24 ft.

The road-bed, or sub-grade, should have the same shape as finished grade.

Pavement.—If intended for very heavy travel, the Telford

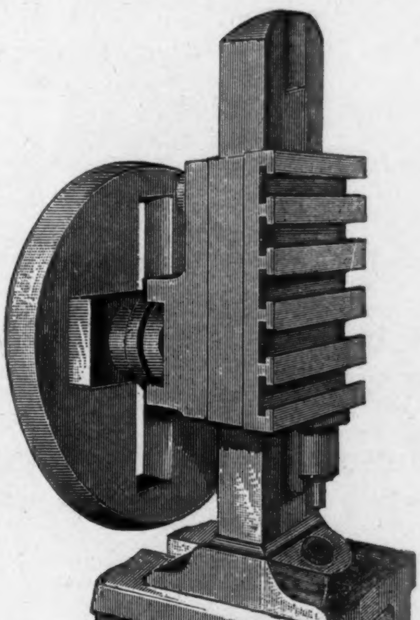
pavement should be put down, but, if for ordinary travel, McAdam will answer. The difference in cost of these two pavements is but slight, and the Telford being much superior, should be given the preference.

A Telford or McAdam road thoroughly constructed and properly maintained will never need reconstruction. The best system of maintenance is that of constant daily attention and repairs. All dirt roads intersecting a paved road should be paved several hundred feet from the intersection in order that as little mud and dirt as possible shall be carried on to the paved road.

Important points to be observed for keeping a road in good condition:

1. All dirt and mud removed as frequently as possible.
2. The entire drainage system carefully maintained.
3. Constant daily repairs and patches wherever and whenever ruts or depressions begin to show.
4. Careful sprinkling three or four times a day in dry weather.
5. The frequent use of a 2½-ton roller.

An English Lathe Attachment.—The accompanying illustration represents an appliance to be attached to lathes and other similar tools for obtaining a vertical reciprocal motion. It is made by Mr. F. M. Rogers, 21 Finsbury Pavement, London, E. C. The action of the apparatus is simple, and will be understood from the illustration. A vertical standard, which can be bolted to the lathe bed, has free to slide upon it a grooved face plate. This can be moved up and down by means of a roller or guide block mounted upon a pin bolted to the chuck plate of the lathe. The pin is free to move backward and forward in the roller path formed on the back of the slide, the length of stroke, of course, depending upon the distance between the pin and the mandrel center. The appliance, which is likely to be found particularly useful in small shops, can be used for a variety of purposes. By placing a cutting tool in the slide rest of the lathe, and feeding either by hand or automatically, a piece of work fixed to the reciprocating plate can be either planed or shaped, or the appliance could be used for punching or shearing if desired.—*Industries*.



Wind Observations on the Eiffel Tower.—The *Revue Scientifique* (Paris) gives the result of observations taken on the Eiffel Tower of the force and direction of the wind, chiefly relating to ascending and descending currents; that is to *vertical* as distinguished from *horizontal* movements of the air. The greatest speed of a vertical current yet observed was during the storm of November 23, 1890, when it reached 34 meters per second, or about 76 miles an hour, the speed, however, being variable. The observations have not been continued long enough to make it safe to formulate any general rules, but M. Angot, who has had charge of the observations, notes the following general results:

1. *Descending* currents are less frequent than ascending currents, and their speed is always less.
2. Every rapid and prolonged fall of the barometer is accompanied by strong *ascending* currents, of a speed of 2 to 4 m. per second, or 4½ to 9 miles an hour. Under these conditions the force of the horizontal current is usually considerable and the sky clouded, so that radiated or reflected heat from the tower itself is not likely to cause the current. Moreover, the same general results were obtained at night as by day.
3. There is no relation between the horizontal and vertical components of the wind. During storms the vertical speed increases more often during the lulls which follow violent blasts.
4. When the barometer rises after a fall, the vertical movement of the air is upward quite as often as downward.
5. Thus far the longest periods of descending currents observed have been when the barometer was rising rapidly, or during long periods of high barometer. In the latter condition there are frequently alternations of ascending and descending currents, each lasting several hours.

A New Tunnel under the Thames.—If the London County Council follows the advice of Sir Benjamin Baker we shall have underneath the Thames at Blackwall one of the largest tunnels of its kind ever constructed. The plan is similar to that which has been adopted in the construction of the City & South London Electric Railway, but whereas the tunnels of that company are 10 ft. in diameter, the one projected at Blackwall has an outside diameter of 27 ft. and an inside of 23 ft. The nearest approach to these dimensions are the Hudson River Tunnel, which is 20 ft. in diameter, and the Sarnia Tunnel, which is 21 ft. In September last Sir Benjamin Baker, under instructions from the County Council, visited these American works, as they present conditions somewhat similar to those which exist at Blackwall, in order to judge of the advisability of adopting the same plans. As the result of his personal study on the spot, the eminent engineer has given it as his opinion that the system is perfectly practicable, and that it should be the one adopted.

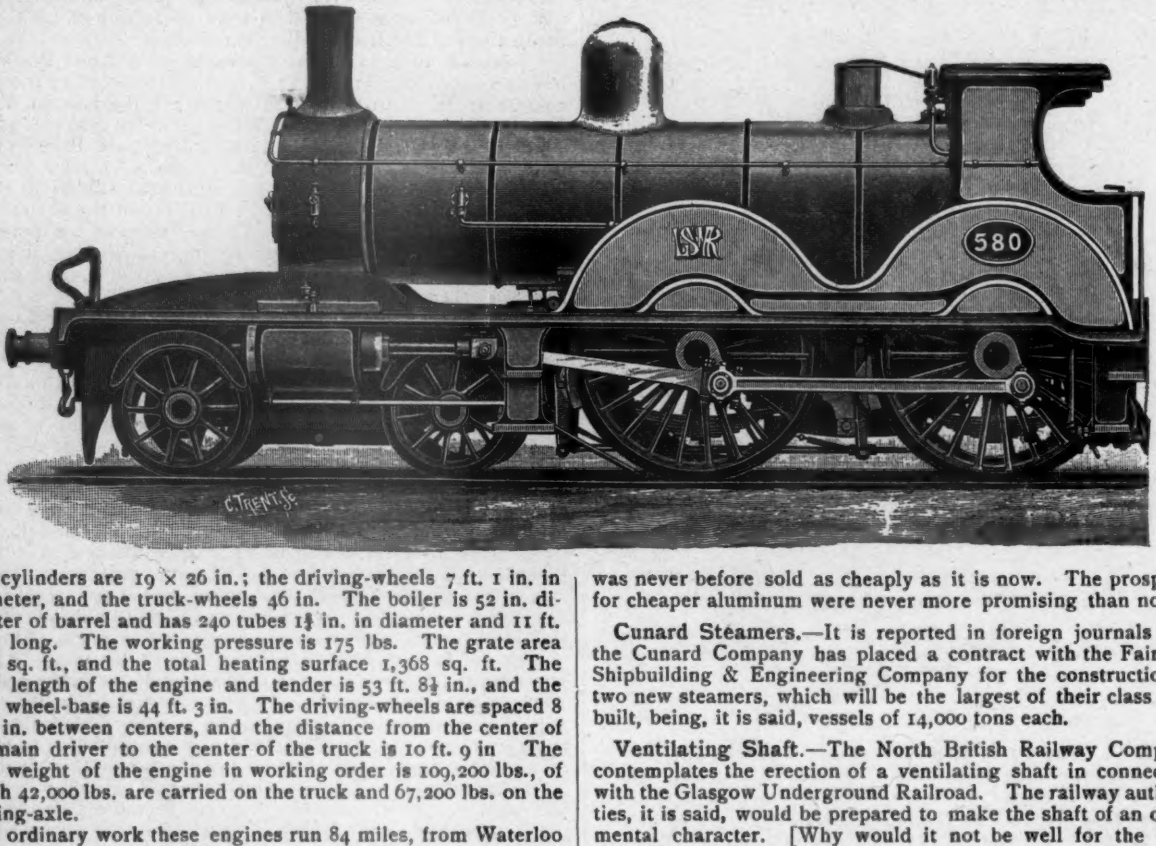
Those who have read descriptions of the South London subway will understand the nature of the work. The tunnel is practically an iron tube built up in segments, which are firmly bolted together. The excavation of the ground is effected by means of a shield with sharp cutting edges, which is advanced 20 in. at a time by means of powerful hydraulic presses. While the soil is being taken out the iron segments are built up, and the shield is then advanced another 20 in. In this way a continuous ring of cast iron is formed. At first the Hudson River Tunnel was driven under the bed of the river without a shield, but in consequence of the inflow of river mud and water, which brought the works to a standstill, the shield was introduced, and the difficulties overcome. In the case of the Sarnia Tunnel the heading had at one point to be driven through soft clay, gravel and sand, but by means of the steel shields and compressed air, progress was made, although at a slower rate than when cutting through the clay. About 5 ft. of tunnel per day was what was accomplished in the gravel, while about double that amount was the average in the clay. It is thus possible by this system of driving to work through any sort of soil, as Mr. Greathead also proved when he came to gravel, sand and water in boring the South London line. At Blackwall there would be no mud, the soil being clay, gravel and sand, so that the conditions would be more favorable on the Thames than on the Hudson. At least 8 ft. of material would remain between the bottom of the river and the top of the tunnel.

Unlike the South London Tunnel, it is proposed to give the one at Blackwall a lining of brick, which, with the iron, would be 2 ft. in thickness. Thus, while the outside diameter would be 27 ft., the inside would be 23 ft. Being in a circle, the whole of the space would not be available for vehicular traffic, but there would be sufficient height for a roadway 18 ft. broad, which would be ample for two lines of vehicles. Many very busy streets in London have less width, and as there will be no interruption from cross traffic the accommodation should be ample. No path is provided for foot passengers, as it would be practically impossible in the space at disposal, and the suggestion is made that they should be provided for either by electric tramways or a smaller and separate tunnel. The Bridge Committee of the County Council, who have the matter in hand, are apparently proceeding very cautiously in the matter. In addition to Sir Benjamin Baker's inquiry, the Chief Engineer has drawn up a report on the subject, and a full-size section of the tunnel is being prepared for the inspection of the members. We may expect in a short time their final decision, and if they should approve the plans we should not have to wait long for a much-needed means of communication between the north and south sides of the river.—*Pall Mall Gazette, London*.

A Long Tunnel.—The Centralia drainage tunnel, near Ashland, Pa., has been practically completed. It is one of the longest tunnels in the United States, and was built to drain a number of coal-mines in the Centralia Basin in the anthracite region. The main tunnel is 6,000 ft. in length, and is 7 × 11 ft. in section. Extensions and branches to reach various mines which it is to serve are about 3,800 ft. in length, making the tunnel some 9,800 ft. in all, to which some further additions will be made.

With the completion of this tunnel a number of the local mines can be extended, and it will be possible to continue the working of the celebrated Mammoth Vein, on which very little has been done for some time past on account of the great expense of pumping.

An English Express Engine.—The accompanying engraving shows engine No. 580 for the London & Southwestern Railroad, which may be taken as a type of the latest design of English express engine. The general features, it will be seen, are those of the American type, four driving-wheels connected and a four-wheel truck, but it differs from an American engine in having inside cylinders and a plate frame. It is stated that in this engine steel castings have been used wherever possible, but the coupling and connecting-rods are of wrought-iron.



The cylinders are 19 × 26 in.; the driving-wheels 7 ft. 1 in. in diameter, and the truck-wheels 46 in. The boiler is 52 in. diameter of barrel and has 240 tubes 1¾ in. in diameter and 11 ft. 4 in. long. The working pressure is 175 lbs. The grate area is 18 sq. ft., and the total heating surface 1,368 sq. ft. The total length of the engine and tender is 53 ft. 8½ in., and the total wheel-base is 44 ft. 3 in. The driving-wheels are spaced 8 ft. 6 in. between centers, and the distance from the center of the main driver to the center of the truck is 10 ft. 9 in The total weight of the engine in working order is 109,200 lbs., of which 42,000 lbs. are carried on the truck and 67,200 lbs. on the driving-axle.

In ordinary work these engines run 84 miles, from Waterloo Station, London, to Salisbury, in 1 hour, 48 minutes, making one stop, the average train being 14 coaches. The usual run is from London to Basingstoke, 48 miles, in 60 minutes, and from Basingstoke to Salisbury, 36 miles, in 48 minutes.

Flight not Improbable.—At the recent annual meeting of the Western Society of Engineers, in an impromptu discussion of aëronautics, Mr. Chanute, the well-known engineer, said:

"The principal difficulty hitherto has been the lack of adequate motive power; that is, the want of a sufficiently light motor in proportion to its energy, to accomplish what birds daily perform; but during the past two months announcements have come from three different parts of the world, that very much lighter motors than any now known to exist are being developed and are being made a partial success. From France comes the statement that Commandant Renard, who has charge of the Aeronautical Department of the French Army, and who, as you remember, some years ago accomplished a speed of 14 miles an hour in a navigable balloon, with an engine exerting 9 H.P., and weighing 1,174 lbs., has now developed another motor, from which he obtains 70 H.P., with a weight of but 946 lbs., or a weight of only 13½ lbs. to the horse power.

"From England comes the news that Mr. Maxim, who is celebrated as an inventor of an electric light, and also of that marvel, the quick-firing gun, which fires 100 shots a minute, has invented a motor of 100 H.P., which only weighs 600 lbs. From our own State comes a still more wonderful fairy tale; from Mount Carmel comes the information that a gas motor has been invented which exerts 100 H.P., and only weighs 250 lbs. Now, remembering all the time that the solution of the problem is chiefly dependent on a light motor, if one-half of the story of Mount Carmel be true, and we can obtain 50 H.P. with 250 lbs. of weight, or even if a quarter be true, or, to speak more accurately and professionally, if only the square root of it be true, and we can get a motor of 10 H.P. weighing only 250 lbs., then an enormous step will have been made toward the solution of the problem."

Expanding Alloy.—An alloy that expands when solidifying, and therefore is valuable to fill cracks in iron castings, is, according to *Revue Industrielle*, produced by fusing together nine parts of lead, two of antimony and one of bismuth.

Aluminum.—At the close of a lecture recently delivered before the Franklin Institute Mr. Joseph W. Richards, said: "Six years ago aluminum sold for $12 a pound, three years ago for $5, to-day it is being sold in England at $1.50, and before this year is out it will probably be down to $1. Aluminum was never before sold as cheaply as it is now. The prospects for cheaper aluminum were never more promising than now.

Cunard Steamers.—It is reported in foreign journals that the Cunard Company has placed a contract with the Fairfield Shipbuilding & Engineering Company for the construction of two new steamers, which will be the largest of their class ever built, being, it is said, vessels of 14,000 tons each.

Ventilating Shaft.—The North British Railway Company contemplates the erection of a ventilating shaft in connection with the Glasgow Underground Railroad. The railway authorities, it is said, would be prepared to make the shaft of an ornamental character. [Why would it not be well for the New York Central Company to entertain a similar idea?—EDITOR.]

Coal Production in India.—According to a recent Indian statistical statement, the production of coal in all India last year was 2,045,359 tons, of which Bengal gave 1,641.354 tons, the Central Provinces 144,465, Assam 116,676, and the Nizam's territory 59,646 tons. In 1880 the total production was 1,019,793 tons, almost wholly in Bengal; in 1883 it was 1,315,976 tons; in 1886, 1,388,487, and in 1888, 1,708,848 tons. In 1880 the only sources of supply were Bengal and the Central Provinces. The latter yielded 31,928 tons in that year, against 144,465 in 1889. The Assam coal-fields were first worked in 1884, when they gave 16,493 tons, and 116,676 in 1889. Coal was first worked in the Punjab in 1887, and last year the yield in that province was 22.835 tons. The Central Indian coal-field was first worked in 1885, and in 1889 it yielded 56,956 tons, while the Nizam's territory, which gave only 3,259 tons in 1887, gave 59,646 tons last year. On the whole, during the last decade the coal production of India doubled. At the commencement of that period the only fields worked were those of Bengal and the Central Provinces; at the end there were mines in addition in four other provinces and territories. In Bengal the yield increased from 988,565 tons to 1,641,354, and in the Central Provinces it increased nearly fivefold.